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THE INFLUENCE OF ULTRA-VIOLET RAYS AND VITAMIN D ON THE GROWTH OF FALL FARROWED PIGS.

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While the main object of this paper is to discuss briefly some experiments conducted at the University of Alberta, it may not be amiss to refer to a few principles in connection with present day livestock production which have a bearing on the special subject under consideration.

The business of producing livestock and livestock products rests on one pivotal principle and that is that all meat, milk and wool-producing animals are developed with the object of supplying some requirement of the human race. The meat that is consumed daily, whether it be beef, pork or mutton, and the milk, cream, butter, cheese, and other dairy products constitute a connecting link between the millions of consumers and those who produce to meet these requirements. Since these articles of diet are a part of the life of the average individual and since the individual develops fairly definite ideas regarding his likes and dislikes in the matter of these articles of diet, he exercises, perhaps unconsciously in most cases, an influence on the methods and practises surrounding livestock production.

The average modern household, when doing business over the butcher's counter, prefers to order small roasts, chops and steaks to large ones. and the average household requires as much milk and cream in the winter when conditions are not ideal for dairy production as in the summer. Smaller families, smaller kitchens and perhaps relatively higher priced meats have given rise to a demand on the part of the consumer for the smaller cuts already referred to. This means that the big steer which provided the large family roast has been replaced by the "baby beef" supplying the small roasts and steaks demanded by the modern beef eater. The boar's head no longer appears at the head of the procession of Christmas viands because the average commercial pig is processed long before he has an opportunity to display his masculine qualities; the "leg of mutton" has been replaced by the "leg of lamb" because the small chop and the six-pound leg of lamb better meet the needs of the modern consumer.

This process of evolution with respect to meat requirements on the part of the consuming public has exerted an important influence on the methods and problems of the livestock producer. The public demand for light weight animals of fine quality has given rise to what might be called

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a speeding up in the process of production or "high pressure" livestoc production. The average meat-producing animal has a short life at presen as compared with earlier times. The combination of consuming demand an the economics of a quick turnover, demand rapid growth on the part o young growing animals, or in other words marketable weight at as earl an age as possible. The steer is marketed at from 12 to 18 months, th pig in from 6 to 8 months and the lamb in from 5 to 6 months.

It will be readily realized that when a pig must increase its weight 10 times, the steer 10 times, and the lamb 12 to 15 times in the short space of time which have been mentioned, the demands for materials for body growth must be fully met if certain conditions of malnutrition are to b avoided. An illustration or two may serve to remind us of the demand mad upon the present day farm animal. The pig of a generation or so ag foraged at large, consuming what roughages he desired, rooting for th tender parts and mineral matter that the dictates of his system called for and fattening to a certain degree upon the nuts and acorns of his fores home; this process could be repeated annually until in time he attaine full growth. If his requirements for body growth were not found in on locality they might be in another. Periods of maintenance only did no conflict with any economic principle; time was no object with this pig. Th buffalo in his natural state, as compared with the modern steer, had a lon life history. He solved his own nutritional problems by a free choice o extensive grazing areas and the functioning of instinct with respect to th finding of suitable mineral deposits. The salt licks of the buffalo are wel known. This method of livestock production is in contrast to the moder scheme of limited pasture areas, periods of close confinement, rations con sisting to a large extent of cereal grains; in general a tendency to remov animals from their natural conditions of feed and environment. Thi tendency on the part of the producer has given rise to nutritional problem because:

1. Limiting the range over which animals may forage has deprived the of the opportunity of a natural balancing of their own rations.
2. Increasing the rate of production makes a heavy demand for materia for body growth and what is perhaps of greater importance, a heav demand on the materials for skeleton growth.
3. Comparatively heavy rationing on cereals, known to be low in ash conten reduces the amount of mineral matter available for skeletal growth an other important functions in the body.
4. Unnatural environmental conditions, such as close housing, elimina some of the natural factors which tend to assist in the utilization of th mineral matter which may be present in the ration.

Of the problems encountered in the modern scheme of livestock pr duction, those revolving around the part played by the mineral elements i animal nutrition and the factors favouring the utilization of these minera in the animal body have received the most attention of recent years. Dai cattle, swine and poultry are the classes of livestock which have been expe mented upon most extensively because these classes have exhibited, to

greater extent than others, pronounced symptoms of disorders traceable to mineral deficiency. This is to be expected when one considers the heavy drain on the dairy cow through the ash content of the milk, the rapid increase in body weight of the pig, and the protracted period of housing which poultry undergo.

That the mineral problem in livestock feeding is significant in Alberta is indicated by the results of several experiments in mineral feeding which have been conducted by the Animal Husbandry Department of the University of Alberta, and by the condition of malnutrition exhibited by much of the livestock, particularly swine, reaching the markets in the Province. Further comment will not be made on the general question of mineral feeding, but attention will be turned to a consideration of the factors which favour the assimilation and utilization of two of the most important mineral elements, namely, calcium and phosphorus. These factors are ultra-violet light and vitamin D.

A study of these factors as related to swine growth in Alberta was suggested by the prevalence of a condition of "stiffness" which has been manifested by considerable numbers of fall farrowed pigs grown during the winter months on the University of Alberta farm, and by the complaints received from farmers of a condition similar to that shown by our own pigs. Under farm conditions this disorder was most noticeable where pigs were closely confined, a common practice on many farms being to shut pigs off completely from sunlight during the winter months. The condition has been referred to as "stiffness", "lameness", "rheumatism" and "rickets" and while these may be regarded as various types of stiffness, it was felt that the symptoms manifested by some of these pigs were quite suggestive of rickets. It might be mentioned, however, that no pathological studies were carried out so that there was no opportunity for checking up on the external symptoms. A preliminary experiment was conducted during the winter of 1926-27 and a rather more detailed study was made during the winter of 1927-28. Similar work is being carried on during the present winter.

Before entering into a discussion of these experiments perhaps it would be well to consider for a few moments some of the history relating to these two nutritional factors.

Ultra Violet Rays.

Light is divided into three divisions of radiation—infra-red or heat rays, visible light and ultra-violet rays or chemical rays. Infra-red and ultra-violet rays are invisible. Ultra-violet rays exert two separate influences on living beings and these influences are exerted by rays from different regions and of different wave lengths. The lethal effect is characterized by the death of the cell exposed to the rays; hence the bactericidal action of ultra-violet light. The other sort of effect is termed stimulative or biologic since stimulation of biologic processes is its commonest expression.

Sources of Ultra-Violet Light.

There are two sources of ultra-violet rays, natural and artificial. The natural source is of course that great body of incandescence, the sun. Season influences affect the intensity of solar radiation. It has been found (*3*) that

in July the maximum range of the spectrum is found, while in winter th smallest amount of ultra-violet radiation is present. In winter the intensit of ultra-violet radiation varies with the altitude, while in summer this con dition does not exist. It would appear that while there may be little ultra violet radiation in sunlight during the midwinter months the amount presen is sufficient to exert a slight but definite biologic effect (*1*).

The quartz mercury vapour lamp is the most common apparatus use in connection with the artificial production of ultra-violet rays. Practicall all studies of the application of ultra-violet rays to livestock production hav involved the use of the quartz mercury vapour lamp.

Biologic Effects of Ultra-Violet Rays.

Ultra-violet rays emitted from natural or artificial sources exert biologic effect. These rays are absorbed by the skin, the short rays penetratin more deeply than the longer rays. In penetrating the epidermal portion o the skin they activate a substance associated with the cholesterol found i the natural grease of the skin. While the earlier view was that cholestero was the substance activated, more recent work indicates that the activate principle is a type of sterol of which ergosterol is the only known representa tive (*2*). It perhaps matters little what the activated substance really is the important consideration being the fact that this substance appears to b transported to all parts of the body where it plays a very important par in metabolic processes.

The Relation Between Ultra-Violet Rays and Vitamin D.

Ultra-violet rays are intimately associated with the food factor com monly known as vitamin D. This food factor on being taken into the bod produces a biologic effect identical to that of ultra-violet rays. They pla the same rôle in animal nutrition—one is replaceable by the other. I would appear that the substance activated by ultra-violet rays under the ski of the animal is vitamin D of animal origin, whereas the food factor presen in certain plant substances is vitamin D of vegetable origin. On the on hand the active principle reaches the body directly by penetration of th ultra-violet rays, and on the other hand, by way of absorption from th intestinal tract and circulation to all parts of the body.

Vitamin D in Relation to Bone Development.

Vitamin D and ultra-violet rays have a definite physiological effect o the composition of bone. These food factors are primarily concerned i the laying down in the bone of the proper proportion of calcium an phosphorus. As normal bone growth takes place calcium and phosphoru are deposited in the Haversian canals as calcium salts. This deposition, how ever, takes place only in the presence of vitamin D. If this factor is lackin these salts are not deposited and normal growth cannot take place. Vitami D may be regarded as a catalyst. The amount of calcium salts deposite is in direct relation to the amount of vitamin D present, at least until a optimum is reached.

The most common manifestation of faulty calcium and phosphoru deposition is the condition known as rickets. In rickets all phases of bo

growth are defective. Some calcium salts are laid down during the early stages of the disease, but these are not deposited normally. The calcium salts that have been previously deposited are re-absorbed by the blood, leaving a meshwork of connective tissue with numerous pores. This weakens the bone so that under the strain of muscles it bends in various directions. In rachitic animals a characteristic enlargement at the joints is seen.

Non-deposition of calcium salts in the bone is accompanied by lowered inorganic phosphorus and calcium content of the blood, although it has been found (*3*) that a lower inorganic phosphorus content of the blood cannot be relied upon as an index to rickets. Elliott, Crichton and Orr (*4*) give the gross symptoms of the disease as slowing of the rate of growth, lethargy and difficulty in locomotion shown by a stiff, stilted gait. Later there follows loss of power of the hind legs and deformities in the long bones, with death ultimately following.

Sources of Vitamin D.

There are two natural sources of vitamin D which are of practical importance in connection with this study, namely, cod liver oil and forage plants in their natural cured state. As an article of commerce, cod liver oil is well known. It is the century old cure for rickets. Vitamin D occurs in the liver and body oils of many species of fish, but the quantity varies widely for the different species. The oil extract of livers is a by-product of the cod fishing industry.

Various forms of roughage contain the anti-rachitic vitamin. It has been found that the anti-rachitic potency of hays is related to exposure to sunshine. Wheat grown in the dark has been found to lack vitamin D, but when grown in the sunlight it exhibited anti-rachitic properties (*5*). Green plant tissue contains more vitamin D than dried plant tissue. It has been determined that the method and conditions surrounding the curing of hays have an important influence on their vitamin D content. Different hays vary as to the amount of this vitamin present, the general opinion being that alfalfa hay is the most prolific source among the common roughages.

Application of Irradiation to Animal Nutrition.

Investigational work has reached a point where it may be stated that the application of these nutritional factors to livestock production is a matter of great importance. During the past few years a considerable volume of evidence has been brought to bear on this point. It will perhaps not be out of place at this point to refer to some experimental findings which will convey some impression of the interest which the animal husbandman has in the factors under consideration.

Among the domesticated animals, poultry is probably the most susceptible to rickets. The disease is often called "leg weakness". Experimenting with growing chicks fed a ration lacking vitamin D and confined indoors, Hart Steenbock and Lepkovsky (*6*) found that in a short period of time rickets developed and death soon followed. When exposed to sunlight, however, chicks grew normally. By irradiating hens Halpin (*7*) was able to maintain egg production. Hart, Halpin and Johnson (*8*) obtained the same result, and they also found that the hatchability of eggs of irradiated hens was

high. The egg production and hatchability of eggs of non-irradiated bird decreased as the trial went on. That the potency of the anti-rachitic facto in eggs is in relation to exposure of the hens was the conclusion reached b Hughes, Payne, Titus and Moore (*9*). Hart (*10*) reared chicks successfull by the addition of vitamin D in the form of cod liver oil in the ratior Dunn (*11*) raised poultry economically in confinement, both for practica and scientific purposes, by the use of cod liver oil in the diet.

Exposure to ultra-violet rays has proven beneficial in the rearing o goats. By irrradiating goats, Hart, Steenbock and Elvehjem (*12*) change a negative calcium balance to a positive calcium balance. At the same tim the calcium and inorganic phosphorus of the blood was increased.

Early workers believed that irradiation played an important part in th physiology of the dairy cow, with regard to growth, milk production an calcium balance. Later work, however, does not bear out this suppositior Gullickson and Eckles (*13*) raised calves successfully in confinement. Har and co-workers (*14*), experimenting with dairy cows in confinement, stat the following:

"1. Utra-violet light has little, if any, direct influence upon the calciur and phosphorus metabolism.
2. Ultra-violet light has no influence, either favourable or adverse, upo the production of milk.
3. Ultra-violet light has no apparent influence upon the calcium an phosphorus content of the milk secreted."

They suggested that cows derive the anti-rachitic vitamin from thei feed. It has been found, however, that irradiating the cow increased th anti-rachitic potency of the milk.

Practically no experimental work has been done in determining th response of horses and sheep to irradiation. Mitchell and Keith (*15*) stat that sheep and horses, as well as cattle, fed rations containing large amount of good roughage and having access to sunlight and pasture part of the yea are in little danger of suffering from calcium and phosphorus deficiency.

Feeding a vitamin D-free diet and in confined quarters, Maynar Goldberg and Miller (*16*) produced rickets in pigs within four months, bu similar pigs exposed to sunlight did not develop this condition. They stat that winter sunlight may be sufficient in amount and efficiency to produc the maximum possible effect in assimilating of calcium and phosphoru The findings of Steenbock, Hart and Jones (*17*) are in accord with th statement. Evvard, Culbertson and Hammond (*18*) found that gains c pigs fed outside were higher than those fed inside, although both lots of pi had free access to sunlight. Accounting for this result, they state that su light was probably responsible, due to the fact that the pigs fed outsi were forced to exposure to sunlight. The feed requirement per 100 poun gain for this lot was considerably lower. This result was corroborated b Bohstedt, Bethke, Edgington and Robinson (*19*). By artificial irradiatio Evvard and colleagues (*20*) lowered the feed requirement as compared t non-irradiated confined pigs. By exposing to sunlight, Steenbock, Hart an

Jones (*17*) were able to increase the calcium and phosphorus content of the bone ash and the calcium and inorganic phosphorus of the blood. Maynard, Goldberg and Miller (*22*) state that the calcium and phosphorus content of bone ash was higher in pigs exposed to sunlight.

By the addition of vitamin D to the ration, through the medium of cod liver oil, Bohstedt (*19*) prevented rickets in confined pigs. Maynard, Goldberg and Miller (*22*) alleviated the condition of rickets in pigs by the addition of cod liver oil to the ration. Evvard (*20*) not only alleviated the condition but increased gains and lowered the feed requirement. By feeding a ration containing cod liver oil, Bohstedt (*21*) maintained normal calcium and phosphorus content of the bone and blood as compared with a check lot where these two mineral elements were reduced in blood and bone as the trial proceeded.

Mention was made earlier in this paper that experiments were started at the University of Alberta in the winter of 1926-27 with a view to determining the relation between natural irradiation and a condition of "stiffness" which was noticed in a number of fall pigs at this station and on farms throughout the country. These experiments will now be discussed.

EXPERIMENT I.

Experiment I, conducted during the winter of 1926-27, was in the nature of a preliminary trial, the object being to see if any suggestive results might be secured. Three groups of pigs, allotted on a litter mate basis, were used in this trial. They were self-fed a ration consisting of equal parts of oats, barley and shorts, the oats being of 2 C.W. grade and the barley 3 C.W. This grain ration was supplemented to the extent of 5 per cent by a mixture made up of 50 per cent tankage (50 per cent protein), 25 per cent alfalfa meal and 25 per cent linseed oil meal. A simple mineral mixture made up of 76.5 pounds slacked coal, 2.5 pounds air-slacked lime, 20 pounds common salt and 1 pound sulphur was self-fed in addition.

The pigs went on trial on December 9th at an average weight of approximately 66 pounds and, on the average, at the age of 90 days. They were housed in a frame shed with windows in the north. Sunlight had no opportunity to penetrate the building during the progress of the experiment. The pigs in Lot I were allowed access to a small runway adjacent to their pen, thereby receiving sunlight *ad libitum*. The pigs in Lot II were not allowed out of their shelter and therefore were not exposed to sunlight during the winter months. The pigs in Lot III were deprived of sunlight until February 15th, after which date the door of their pen was opened and they were allowed the freedom of their outside runway.

The results of this experiment interpreted in rate of gains and feed requirement for 100 pounds of gain is shown in table 1.

It will be noted that the gains of the pigs deprived of sunlight are very low as compared with the gains made by the other two groups. In this connection the condition of the pigs in this group must be considered. By January 26th one pig developed stiffness and by February 23rd another pig showed symptoms of the same condition. By March 23rd two more pigs

TABLE 1. *Rate of gain and feed requirements—Experiment I.*

	Lot I Sunlight	Lot II No Sunlight	Lot III. Sunlight after Feb. 15th.
No. of pigs in group	8	8	8
Average initial weight	66.09 lbs.	66.67 lbs.	67.21 lbs.
Average final weight	192.0 "	167.38 "	192.04 "
Average daily gain	1.12 "	.85 "	1.11 "
Average daily feed consumed	5.57 "	4.78 "	5.57 "
Feed required for 100 lbs. gain	498.96 "	564.73 "	501.70 "

were developing stiffness and at the close of the experiment four out of the eight pigs were in a badly crippled condition. The external symptoms of these pigs were strongly indicative of rickets. As soon as stiffness appeared the rate of gain was reduced and since four out of eight pigs were affected, the average rate of gain for the group was materially reduced. The four pigs which remained normal made very satisfactory gains.

The gains of Lots I and III are very close, indicating that, so far as the rate of growth is concerned, the group deprived of sunlight during the early part of the winter did not suffer. A study of bi-weekly weights on the two groups, however, indicates that the pigs in Lot I made more uniform gains than those in Lot III throughout the experiment.

The feed requirements for 100 pounds of gain is lowest for the group having access to sunlight during the entire experiment. The difference in the requirements of Lots I and III is not great, but may be suggestive of slightly more active physiology in the "sunlight" group. The condition of stiffness in Lot II was accompanied by the high feed requirement shown in the table.

Pathological evidence of a rachitic condition in the pigs in Lot II in this experiment is lacking, but external symptoms pointed toward this type of stiffness. The slow gains and high feed requirement of the affected group show that rather a serious case of faulty nutrition developed. On the basis of previous experiments alluded to, it would seem reasonable to deduce that the lack of exposure to ultra-violet rays was the factor contributing to the unsatisfactory results. Since no cases of stiffness developed in the pigs deprived of sunlight until February 15th, it would appear that they carried a sufficient reserve of vitamin D to bridge the gap of eleven weeks from December 9th to February 15th. On the other hand, the small amount of alfalfa meal fed in the supplemental mixture (1.25 per cent of total ration) might have contained sufficient of the anti-rachitic element to prevent any nutritional complication over the eleven week period.

As a sequel to this experiment the four pigs in Lot II which were badly crippled at the conclusion of the experiment on April 6th were allowed the freedom of their outside runway and exposure to sunlight. They were still maintained on the experimental ration. The condition of these pigs may be noted in the accompanying illustrations. Chart I shows the rate of growth of the four pigs from December 9th to June 16th. The improvement in the rate of growth following exposure to sunlight on April 6th is quite marked. By June 16th all of these pigs had made a complete recovery from the condition of stiffness, although a slight enlargement of the joints remained in some of the worst cases.

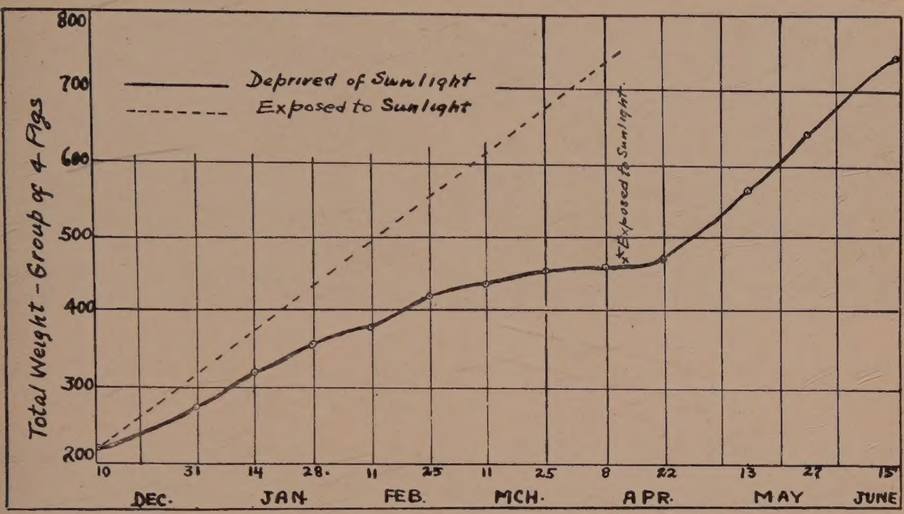

CHART I.
Rate of gains of pigs before and after exposure to sunlight (Lot III), Experiment I. The broken line indicates rate of growth of pigs in Lot I, exposed to sunlight during entire experiment.

FIGURE 1. Lot I—Experiment I—Sunlight. Average daily gain Dec. 9, 1926 to April 6, 1927, 1.12 lbs. No cases of stiffness developed in this group.

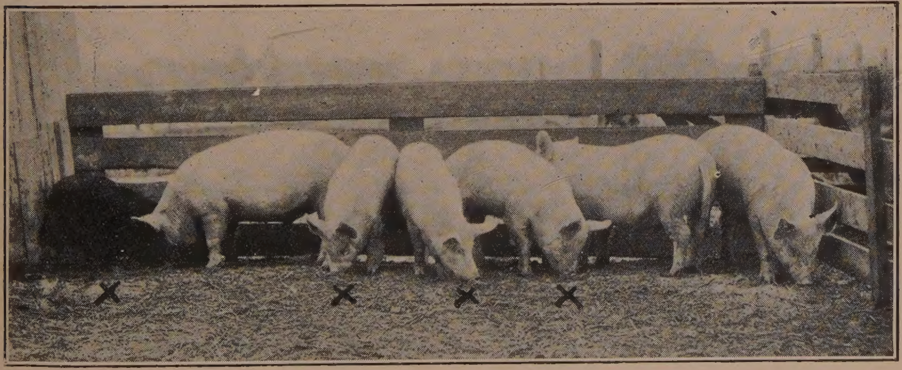

FIGURE 2. Lot II—Experiment I—No sunlight. Average daily gain Dec. 9, 1926 to April 6, 1927, .83 lbs. Pigs marked "x" developed severe cases of "stiffness".

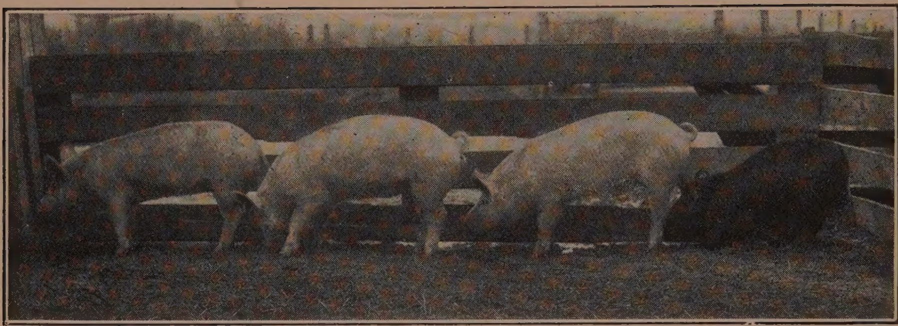

FIGURE 3. Lot II—Experiment I—(No sunlight). Four pigs in this group which developed severe cases of stiffness. The Tamworth pig in the right hand corner was so badly affected that it travelled on its knees when urged to move. The growth curve for these pigs before and after exposure to sunlight is shown in Chart I.

FIGURE 4. Pig out of Lot II, Experiment I (no sunlight). Weight Dec. 10, 1926, 51 lbs. Wt. April 13, 1927, before exposure to sunlight, 68 lbs. Wt. June 15, after exposure to sunlight, 120 lbs. Photo taken April 1, 1927.

EXPERIMENT II.

During the winter of 1927-28 a second experiment was conducted. The general scheme was in line with the work of the previous winter, but in addition a group fed cod liver oil was included and provision was made for analysis of composite samples of the feeds fed and determinations of the inorganic calcium and phosphorus content of the blood of representative pigs. Ash analyses were also made of the femurs of litter mate pigs out of the various groups. These analyses and determinations constituted a check on the calcium and phosphorus intake of the various groups as well as on the utilization of these elements. The period of the experiment was from November 23rd to March 21st, when the pigs attained a marketable weight.

The objects of this experiment might be stated as follows:

1. To study the effect of sunlight (ultra-violet rays) on calcium and phosphorus utilization in fall pigs.

2. To study the effect of adding vitamin D to the ration, through the medium of cod liver oil, on calcium and phosphorus utilization in fall pigs.
3. To note the influence of ultra-violet rays and vitamin D as factors in preventing "stiffness" in fall pigs.

Pigs Used and Methods of Allotment.

In this experiment eight pigs were placed in each group. Allotment was made on a litter mate basis, that is, each pig in a group had a litter mate in the other groups in the experiment. In this way hereditary influences were avoided as nearly as possible and a very even distribution as to size, type and condition was secured. The average initial weight of the pigs used was 56.6 pounds and the average initial age 72.6 days.

Rations Fed.

The grain mixture and supplemental mixture fed was the same as in Experiment I, namely, oats (2 C.W.), barley (3 C.W.) and shorts, equal parts by weight with 5 per cent of the mixed supplement already outlined. Cod liver oil was fed at the rate of half a pound per 100 pounds of grain mixture in Lot IV. Ground limestone was fed to each group at the rate of two pounds per 100 pounds of grain.

With respect to rations and method of treatment the various lots were dealt with as follows:

Lot I Basal Ration, ground limestone (Sunlight at liberty).
Lot II Basal Ration, ground limestone (No sunlight).
Lot III Basal Ration, ground limestone (Sunlight after Feb. 15).
Lot IV Basal Ration, ground limestone (No sunlight. Cod liver oil ½ lb. per 100 lbs. grain mixture).

Indoor self-feeding was practised in all lots. Salt was fed *ad libitum*. Water with the chill removed was supplied three times daily.

General Nature of the Ration.

The basal ration referred to had a nutritive ratio of 1:5.1. Containing animal and vegetable protein, it was considered adequate from the standpoint of protein. It was assumed that the variety offered in the grain and supplemental mixtures would make provision for sufficient phosphorus. In order to insure an adequate supply of calcium the ground limestone was added. In compounding the ration the guiding principle kept in mind was to give the nutritional factors under consideration ample opportunity to exert their maximum influence, rather than to use an inadequate ration which might reasonably be expected to induce a condition of stiffness in some of the groups. In adding the small quantity of alfalfa meal for protein variety, it was thought that the vitamin D content would not be sufficient to introduce a complication.

An analysis of the ash of the feed used is shown in table 2.

In order to determine the degree of purity of the limestone a sample was analysed, with the following result:

Silica	2.01	per cent
Iron Oxide	0.42	"
Alumina	0.51	"
Carbonate of Lime	93.53	"
Carbonate of Magnesia	2.92	"
Vegetable matter	0.34	"

TABLE 2. *Analysis of feeds.*

	Oats	Barley	Shorts	Supplement.
% Ash	2.78	2.85	3.85	12.73
Analysis of Ash				
Potash (K_2O)	15.76	22.10	30.60	7.01
Soda (Na_2O)	4.50	5.60	2.68	2.60
Lime (CaO)	3.83	2.43	2.58	45.60
Magnesia (MgO)	6.93	9.98	13.15	2.39
Iron Oxide (Fe_2O_3)	0.14	0.24	0.16	0.10
Alumina (Al_2O_3)	.00	.00	.00	.00
Phosphoric Acid (P_2O_5)	24.30	35.43	48.49	38.59
Sulphates (SO_2)	0.32	0.13	0.18	1.72
Silica (SiO_2)	43.90	23.50	1.49	1.82
Chlorine (Cl)	0.52	0.42	0.54	0.32
Carbon Dioxide (CO_2)	.00	.00	.00	Traces

The ground limestone as secured from a local cement company was considered rather coarse so was reground to a state where 82.96 per cent passed through a sieve of 130 meshes per square inch.

CALCIUM AND PHOSPHORUS INTAKE.

Since the utilization of calcium and phosphorus was the main item under consideration the daily and total intake of these elements was calculated with the following result:

TABLE 3. *Calcium and phosphorus intake.*

	No. of Pigs	Per 100 pounds live weight daily		Total Consumed	
		Ca	P.	Ca	P.
		Lbs.	Lbs.	Lbs.	Lbs.
Lot I—Sunlight	7	.04300	.02384	45.48	26.78
Lot II—No sunlight	6	.04402	.02628	39.15	23.04
Lot III—Sunlight after Feb. 15th	7	.04196	.02482	44.16	26.25
Lot IV—Cod liver oil	7	.04153	.02422	44.86	26.39

A uniformity in the rate of feed consumption is reflected in the uniformity in the calcium and phosphorus intake of the various groups. The calcium and phosphorus ratio of the ration fed is shown to be 1.7:1, while the ratio of the blood and bone proved to be 2:1. That the supply of these two elements was abundant for ordinary requirements is indicated by the experiments of Lawes and Gilbert, which point to the amounts of 2.11 grams and 1.27 grams as the average daily retention of calcium and phosphorus in a six months old pig. Allowing for even a 50 per cent assimilation the amounts fed provided for a liberal margin of safety.

CALCIUM AND PHOSPHORUS CONTENT IN BLOOD.

Since the calcium and phosphorus content of the blood seems to be quite definitely related to the condition of rickets or at least defective bone building, it was thought well to make determinations on blood samples from litter mate pigs. Some of these blood samples were secured at time of slaughtering while others were secured from the tail at intervals throughout the progress of the experiment. In order to make clear the genetic relation-

ship between the pigs whose numbers appear in the following tables, it might be stated that numbers 484, 489, 486 and 492 are litter mate pigs, slaughtered at the commencement of the trial. Blood samples were secured and femurs retained for ash analysis. Nos. 487, 483, 490 and 488 were litter mates of the first four. Blood samples were taken from these pigs by the tail method on December 4th and 29th, January 26th and February 16th. They were slaughtered on February 16th and femurs retained for ash analysis. Nos. 835, 833, 836 and 839 were litter mates from which blood samples were secured on March 15th and 23rd. These pigs were slaughtered on March 23rd at the conclusion of the experiment and femurs kept for ash analysis. The results of the determinations of inorganic calcium and phosphorus in the blood are shown in the following tables.

TABLE 4. *Calcium and phosphorus content of blood in Lot I (Sunlight)*

Date	Pig No.	Mgm. per 100 c.c. blood serum	
		Ca.	P.
November 17	484	14.41	5.71
December 4	487	13.40	5.46
December 29	487	14.47	6.52
January 26	487	14.40	5.40
February 16	487	13.20	6.14
March 15	835	16.05	6.90
March 23	835	15.69	6.98
Average		14.517	6.158

TABLE 5. *Calcium and phosphorus content of blood in Lot II (No sunlight)*

Date	Pig No.	Mgm. per 100 cc. blood serum	
		Ca.	P.
November 17	489	14.01	5.60
December 4	483	15.04	5.48
January 3	483	15.97	5.44
January 26	483	15.40	5.06
February 16	483	15.28	7.50
March 15	833	15.19	7.68
March 23	833	14.84	8.84
Average		15.104	6.514

TABLE 6. *Calcium and Phosphorus content of blood in Lot III (Sunlight after Feb. 15th)*

Date	Pig No.	Mgm. per 100 c.c. blood serum	
		Ca.	P.
November 17	486	16.11	6.15
December 4	490	16.11	6.30
December 29	490	16.58	7.82
January 26	490	16.00	5.02
February 16	490	15.50	5.94
March 15	836	13.95	9.28
March 23	836	13.10	9.36
Average		15.335	7.124

TABLE 7. *Calcium and phosphorus content of blood in Lot IV (Cod liver oil)*

Date	Pig No.	Mgm. per 100 cc. blood serum	
		Ca.	P.
November 17	492	14.50	5.78
December 4	488	14.04	5.10
December 29	488	15.47	8.28
January 26	488	15.50	5.66
February 16	488	15.60	7.32
March 15	839	14.99	7.14
March 23	839	15.68	9.58
Average		15.111	6.980

A condition which presents itself at the outset in considering the inorganic calcium and phosphorus content of the blood is the part which individuality may play. Litter mate pigs, newly weaned, and from which blood samples were taken on November 17th show Ca contents of 14.41, 14.01, 16.11 and 14.50 in Lots I, II, III and IV respectively. This occurrence appears to make comparisons on the basis of average composition by lots unreliable. The most reliable study in these tables would appear to be a comparison of pigs Nos. 487, 483, 490 and 488 in Lots I, II, III and IV from which blood samples were secured during the period from December 4th to February 16th. The various groups show considerable variation in calcium and phosphorus content on the different dates of sampling. With the exception of Lot IV progressive increases or decreases are not shown. The low calcium content in Lot I (sunlight) on February 16th is difficult to explain, when the P. content of the group shows an appreciable increase. The most significant group from the standpoint of calcium content of the blood appears to be Lot IV (cod liver oil) where steady increase is shown as the trial progressed. Decreases in calcium and phosphorus which would be suggestive of faulty assimilation and utilization are not shown in any group. The fairly uniform trend throughout the trial indicates that these processes were proceeding in a fairly normal manner, a condition which was borne out in practice since no cases of stiffness in any degree were encountered. In connection with the interpretation of these results it is no doubt well to keep in mind the small amount of alfalfa meal fed in the ration and the fact that these pigs were fall farrowed from sows on pasture while pregnant, the pigs also having access to pasture while nursing.

Composition of Bone Ash.

The percentage of ash in the bone is an indication of bone strength and is a reliable guide as to the utilization of mineral elements in bone development. Variations in calcium, phosphorus and magnesium content of bone ash should indicate varying degrees of utilization of these elements. In order to study the effect which the experimental factors under consideration had on the composition of the bone in the various groups, ash determinations were made on femurs from litter mate pigs. The results of these analyses are shown in the following tables.

Table 8. *Bone analysis, Lot I (Sunlight)*

Date	Pig No.	Ash	Ca.	P.	Mg.
		%	%	%	%
November 17	484	54.09	36.16	18.75	.861
February 16	487	60.61	38.87	18.44	.737
March 23	835	62.67	38.44	18.52	.746
Average		59.123	37.813	18.570	.781

Table 9. *Bone analysis—Lot II (No sunlight)*

Date	Pig No.	Ash	Ca.	P.	Mg.
		%	%	%	%
November 17	489	53.65	36.50	18.90	.789
February 16	483	59.91	38.90	18.12	.768
March 23	833	61.58	37.50	18.32	.712
Average		58.38	37.633	18.446	.756

TABLE 10. *Bone analysis—Lot III (Sunlight after February 15th)*

Date	Pig No.	Ash	Ca.	P.	Mg.
		%	%	%	%
November 17	486	53.70	36.68	19.07	.793
February 16	490	61.40	38.37	18.49	.808
March 23	836	63.26	37.85	18.84	.919
Average		59.453	37.633	18.80	.840

TABLE 11. *Bone analysis—Lot IV (Cod Liver Oil)*

Date	Pig No.	Ash	Ca.	P.	Mg.
		%	%	%	%
November 17	492	52.10	36.87	18.53	.803
February 16	488	61.06	39.04	18.22	.753
March 23	839	61.54	37.90	18.50	.820
Average		58.20	37.936	18.416	.792

The percentage of ash of the bones in all lots is remarkably uniform, and in comparing these analyses with those obtained at other stations (*21*) it may be stated that ash percentages ranging from 58 per cent to 59 per cent indicate satisfactory utilization and very acceptable strength of bone. None of the bones taken from pigs at the conclusion of the experiment (March 23rd) indicates any mineral deficiency or tendency toward faulty assimilation.

While it has been pointed out that individuality undoubtedly plays some part in determining bone composition, it is of interest to compare the rate of increase in the percentage of ash between the initial and final dates of the experiment. The percentage of ash increased 15.86 per cent in Lot I, 14.78 per cent in Lot II, 17.80 per cent in Lot III and 18.12 per cent in Lot IV. These figures can undoubtedly be given a more definite interpretation than those relating to blood samples, since the conditions surrounding the sampling and anlysis of bone are less liable to variation. The smallest increase in ash content took place in Lot II where the pigs were deprived of sunlight during the entire experiment and the largest increase occurred in Lot IV where cod liver oil was fed. So far as the calcium content of the bone is concerned, the greatest increase occurred in Lot I (sunlight) and the smallest increase in Lot II (no sunlight). With regard to the ash analysis it cannot be said that any outstanding differences are revealed. It would appear that the basal ration used possessed a fairly high degree of anti-rachitic potency—a condition which obviated the possibility of ultra-violet rays and vitamin D exerting any marked influence.

RATE OF GAINS.

The rate of gains made by the pigs in the various groups is shown in table 12 and is graphically represented in Chart 2.

TABLE 12. *Average daily gains.*

Lot No.	Average daily gain (lbs.)
I—(Sunlight)	1.10
II—(No sunlight)	1.06
III—(Sunlight after Feb. 15th)	1.12
IV—(Cod liver oil)	1.18

The gains in all groups must be considered satisfactory and in all lots except Lot I are higher than an eight year average of 1.08 pounds for fall pigs on a standard grain and tankage ration at this station. The difference

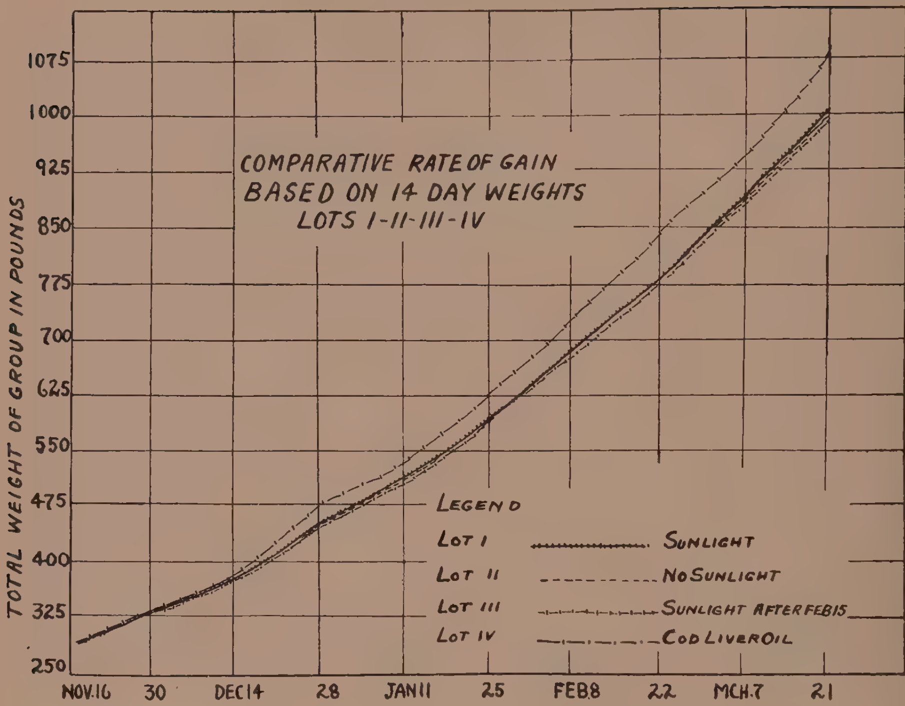

CHART II.

in gains between the highest and lowest groups is sufficient to be regarded as significant, but between some of the others it is too slight to be of material consequence. The pigs deprived of sunlight made the lowest gains with the group receiving cod liver oil making 11.32 per cent higher gains. The slightly higher gains in Lot III as compared with Lot II are probably due to the pigs in Lot III being in confinement during the major portion of the experimental period and thus securing less exercise.

FIGURE 5. Lot IV, Experiment II (Cod Liver Oil). Average daily gain, Nov. 16, 1927, to March 23, 1928, 1.18 lbs.

In order to obtain a more detailed comparison of the rate of gains made by the various groups, fourteen day weights of five pigs carried throughout

the entire experiment are plotted on Chart II. The growth curves show rather a remarkable uniformity in the four groups. The gains of Lot I were fairly consistent throughout the experiment, while the gains of Lot II showed a tendency to fall off during the latter part of the experiment. This condition is rather significant. The gains in Lot III improved after Feruary 15th, probably due to the beneficial effects of exposure to sunlight. The curve for Lot IV (cod liver oil) shows that this group maintained a lead in rate of growth after the first three weeks of the experiment.

Feed Requirements.

Normal growth in pigs results from proper rationing and proper physiological activity within the body. These two factors working together result in a condition generally spoken of as"thrift". Any physiological derangement has a tendency to produce "unthriftiness" and the degree of unthriftiness is closely related to the amount of feed required to produce 100 pounds of gain. In this experiment the feed requirement closely correlated with the degree of thrift. While unthriftiness in the strictest sense of the word was not evident in any group, the degree of thriftiness, an indicated by condition of hair and skin and general vigour, was closely linked with feed requirement. The pigs in Lot IV were most thrifty in appearance at the close of the experiment, while those in Lot II were the least thrifty. The feed requirements for 100 pounds gain are shown in table 13.

Table 13. *Feed required for 100 lbs. gain—Expt. II.*

Feeds	Lot 1 Sunlight	Lot II No. Sunlight	Lot III Sunlight after Feb. 15	Lot IV Cod liver oil
	Lbs.	Lbs.	Lbs.	Lbs.
Grain	455.61	473.46	434.34	416.70
Mixed supplement	24.00	24.90	22.84	21.94
Limestone	9.6	9.96	9.14	8.77
Salt	1.39	1.94	1.25	1.49
Cod liver oil	———	———	———	2.20
Total	490.60	510.26	467.51	451.1

In interpreting the feed requirements it may be well to point out that the average final weights of the pigs in the various groups were 190.9, 187.8, 194.7 and 201.8 in Lots I, II, III, and IV respectively. Comparing these feed requirements with an eight year average of 510.56 pounds for fall pigs on a standard grain and tankage ration at this station it may be noted that with the exception of Lot II (no sunlight) they are appreciably lower. Comparing the feed requirements on a percentage basis it is found that Lot II confined indoors had a 13.11 per cent higher feed requirement than Lot IV and 4.07 per cent higher than Lot 1. The lower feed requirement of Lot III as compared with Lot I may be accounted for on the basis of a lower basal requirement resulting from close confinement during the initial phase of the experiment. The feed requirements in the various groups are graphically presented in Chart 3.

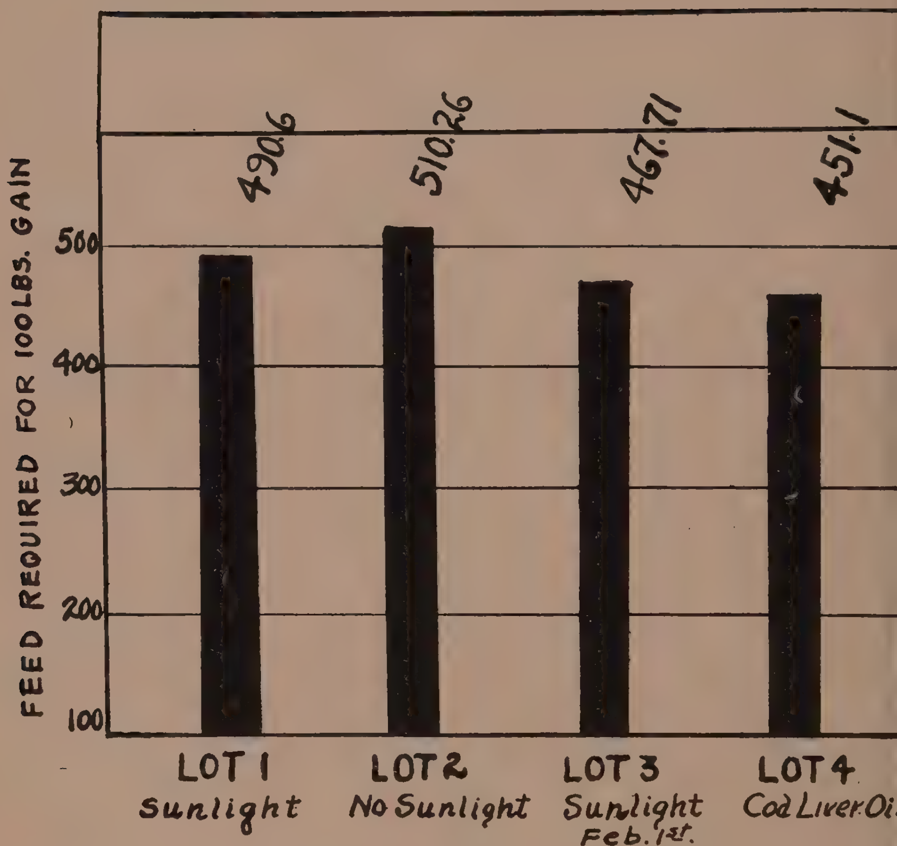

Chart III.
Feed requirements of various groups in Experiment II.

Summary.

The development of several acute cases of "stiffness" in the pig deprived of sunlight in Experiment I and the decreased gains and highe feed requirement associated with a smaller increase in the ash percentag of bone in pigs similarly treated in Experiment II indicate that fall farrowe pigs are benefitted by exposure to sunlight. Pigs deprived of sunlight durin the early part of the winter did not develop any cases of "stiffness", but study of their growth curve shows an improvement in the rate of gains afte exposure to sunlight. A study of feed requirements suggests bette physiological activity on the part of pigs exposed to ultra-violet rays o natural origin. While the intensity of the ultra-violet rays in sunlight i this latitude during the winter months may not be great there is evidenc that these rays are of biologic value.

The feeding of cod liver oil as a source of vitamin D produced result which were quite significant. The increase in percentage of calcium an phosphorus in the blood and increase in percentage of ash in bone of pig fed cod liver oil suggests that vitamin D was an active agent in stimulatin

better utilization and assimilation of these elements. While to some extent the increased gains and lowered feed requirement of pigs fed cod liver oil may be attributable to the nutritive value of the oil itself, the excellent state of "thrift" displayed by these pigs indicated a generally efficient state of tissue and bone metabolism. In an economic sense the feeding of cod liver oil was sound practice. Cod liver oil purchased at $2.00 per gallon had a replacement value of $3.75 per gallon.

Conclusions.

1. Exposing fall pigs to sunlight resulted in an increase in the percentage of bone ash and percentage of calcium in the ash.
2. Supplying vitamin D through the medium of cod liver oil brought about an increase in the percentage of bone ash and an increase in percentage of calcium in the bone.
3. While there was some variation in the percentage of bone ash in the various groups, all lots yielded what might be regarded as strong bone.
4. Owing to the part played by individuality, calcium and phosphorus determinations on blood samples did not yield results which were particularly suggestive.
5. The small proportion of alfalfa meal supplied in the basal ration combined with the ample calcium and phosphorus supply of the supplemental mixture and ground limestone may have served to prevent any tendency toward rachitic developments in Experiment II.
6. Calcium and phosphorus were present in the bone in the ratio of 2:1, and in the ration fed in the ratio of 1.7:1.

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Errata

Several errors appeared in our last issue (May, 1929) and should be corrected as follows:—

Page 601, 2nd line from bottom: (*6*) should read (*5*).
Page 602, 4th " " top (*8*) " " (*6*)
Page 602, 10th " " " (*9*) " " (*7*)
Page 602, Table 4. Delete (I)
Page 603, Line 1 below Table: (*11*) should read (*9*)
Page 604, Top line should read "Tentative American Method (*9*)."
Page 605, 5th line from bottom should read "much slower determination by weight (*9*)."
Page 606, Delete (*11*) from 2nd and 4th headings.
Page 606, Last line of 2nd and 4th paragraphs, add (*9*).
Page 607, Last line under heading "Protein", add (*10*).
Page 607, " " " "Mellowness" add (*11*).
Page 608, 2nd line from top, add (*11*).
Page 607, 1st line under heading "Growth": "male" should read "malt."
Page 608, Paragraph 2, line 8, "nitrate" should read "filtrate."
Page 609, Bibliography should read as follows:—

1. Wahl and Henius, American hand book of brewing and malting. Vol. 2, p. 847.
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10. Official methods of agricultural chemists.
11. Wahl and Henius. American hand book of brewing and malting. Vol. 1, pages 548-551.

Page 611, First line of article by C. W. Leggatt should read: "In a previous communication (*1*) this question has been," etc.
Page 628, Paragraph 2, line 4, "expense" should read "response".

A STUDY OF CHURN SANITATION*

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[Received for publication March 8, 1929]

The sanitary quality of dairy products is an important factor in the advancement of the dairy industry. The development of mould in some creamery butter has been detrimental to the establishment of markets that otherwise are open to our products. Since practically all Canadian creamery butter is made from cream pasteurized at relatively high temperatures (170° F. for 10 minutes or more), the presence of moulds has been accepted as indicative of lack of sanitation in the handling of the product subsequent to the pasteurization of the cream.

In 1926 Hood and White (*4*) presented data to show the sources from which mould and yeast contamination may come and established a mould and yeast count basis for grading the sanitary quality of butter. Two years later Hood (*5*) suggested a modified score card for butter in which the mould and yeast count was given a value of 10 out of a possible score of 100. Butter having 10 or less moulds and yeasts per gram was given a full score of 10 points. That it is not an easy undertaking to produce mould- and yeast-free butter is the experience of the 149 creameries that entered the "World's Butter Review" Mould and Yeast Contest in 1928 (*8*). The buttermakers of the competing creameries put into practice their best creamery technique.

The churn is the most important piece of equipment with which the cream comes in contact subsequent to pasteurization. Lund (*7*) in 1920, discussing yeasts and moulds, made the significant statement that "The churn is the most unsanitary piece of equipment found remaining in the modern creamery." Hood and White state that "The churn is, undoubtedly, the most difficult piece of equipment to keep clean." Brown (*2*) in 1928 presented photographs and data to show the possibility of crevices in the workers of a churn as being responsible for the harbouring of contamination.

Scope of the Problem

The work reported herewith was undertaken, firstly, to verify the significance of a presumably clean churn as a source of the contamination to which butter is subject and secondly, to determine how this source of contamination may be eliminated.

Equipment and Methods

Two factory churns, having capacities of 300 and 450 pounds of butter respectively, were used. Both had been equipped with new rolls less than a year before these experiments were carried out. This should ensure that they were in good mechanical condition. After use the churns were rinsed with hot water. Then they were washed thoroughly with a solution of washing soda in hot water, the churn being about one third full and run for fifteen minutes in high gear. Finally they were rinsed with steaming hot water, drained, turned with the doors up and, after drying for a couple of hours,

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*Grateful appreciation to the Department of Bacteriology of the Manitoba Agricultural College is hereby given. Media and sterile apparatus were provided for use in mould and yeast and bacterial counts.

covered with muslin covers as a protection from air contamination. Before use each time, unless otherwise stated in these experiments, the churn was filled one third full and the water brought to near boiling by the introduction of live steam. The churn was closed and revolved in high gear for 15 minutes and later cooled for use. At irregular intervals once in two weeks the churns were limed, in which cases the lime solution was left in the churn over night.

The contamination attributed to the churn was determined by introducing 12 gallons of water, sterilized at 15 pounds steam pressure for 1 hour, and running the churn in high gear with workers in motion for a period of 10 minutes, removing the water from the churn to a sterile container and determining the mould and yeast count according to the procedure outlined by Hood (*6*). The necessary control examinations of the water were made regularly.

Series I. Experiments on Churns Ready for Use

In the first series of 11 experiments the sterile water was dumped into the churn as soon as it was cool enough after having been prepared for use by scalding in the regular way described under methods. The results, which are given in table 1, show counts ranging from 13 to 312 mould and yeast colonies per c.c. In one case the number was too great to be counted. Both churns showed contamination.

Table 1. *Mould and yeast colonies per c.c. of water. A churn presumed to be clean and ready for use, was loaded with 12 gallons of sterile water and run in high gear with workers in motion for 10 minutes. The water was drawn off and mould and yeast counts made.*

Run	Churn	Moulds and yeasts per c.c.	Run	Churn	Moulds and yeasts per c.c.
1	A	64-58	6	A	11-15
2	B	uncountable in duplicate	7	A	281-279
3	B	75-75	8	A	100-108
4	A	43-49	9	A	241-243
5	A	37-29	10	B	336-288
			11	A	33-35

Series II. Experiments on Churns, Treated Specially Before Use

The second set of experiments was carried out in an attempt to reduce the contamination proven, as shown above, in spite of what might be called ordinary practical treatment. Four factors were considered namely: (1) the sterilizing agent, (2) the amount of sterilizing medium in the churn, (3) the temperature of the medium and (4) the time of exposure to treatment. Various combinations of the four provided the conditions for the 16 experiments.

Two sterilizing agents were considered,—heat and a chemical. In the heat method, water in the churn was heated by the introduction of live steam from the hose. Then the churn was closed and run, or allowed to stand for different periods of time. In the latter case it was turned over at 2 or 3 intervals to ensure that all parts of the churn were exposed to treatment. A commercial sterilizer, labelled as containing 10 per cent available chlorine, was used for the chemical treatment. Various dilutions in water were tried. The churn was handled as in the heat treatment.

Two amounts of sterilizing medium were used. The churn was filled about one third full in some experiments; in others, about two thirds full.

When heat was used as a sterilizing agent the temperature of the water from the churn, as found at the end of the holding period, varied from 172 to 192 degrees F., the longer periods of holding having caused greater cooling of the medium. When the chlorine-producing solution was used the temperature ranged from that of tap water to 176 degrees F.

The time of exposure to the different treatments varied from 10 minutes to 3 hours.

The contamination remaining in the churn after treatment was determined as in the previous series. In several of the experiments bacterial contamination was determined also, the medium used being standard agar and the procedure as described in Standard Methods of Milk Analysis of the American Public Health Association (1923). The details of the experiments and the results obtained are presented in table 2.

TABLE 2. *Mould and yeast and bacterial colonies per c.c. of water. A churn, treated specially, was loaded with 12 gallons of sterile water and run on high gear with workers in motion for 10 minutes. The water was drawn off and mould and yeast and bacterial counts made.*

Run	Churn	Treatment	Moulds and yeasts per c.c. of solution from churn	Contamination in 12 gals. sterile water. Moulds and yeasts per c.c.	Bact. per c.c.
1	A	⅔ full, water 182 F, stand 1 hour		0-0	7400-6700
2	A	⅔ full, water 176 F, 1-400 B*, run 10 mins.		0-0	2600-2200
3	A	⅓ full, water 100 F, 1-400 B, run ½ hour		0-0	18800-16700
4	A	⅔ full, water 100 F, 1-400 B, run ½ hour		0-0	8500-10000
5	B	⅓ full, water 190 F, run 15 mins.	0-0	230-280	-
6	B	⅓ full, steam 210F, water 192 F, run 15 mins.	0-0	50-56	-
7	B	⅔ full, cold water 1-500 B, run 2 hrs, workers in low gear at intervals ½ hour		7-15	1800-1600
8	A	⅓ full, cold water 1-400 B, worked in low 10 mins, run in high 35 mins.		0-1	14300-
9	B	⅓ full, cold water 1-500 B, worked in low 5 mins. run on high 25 mins.		29-21	-
10	A	⅓ full, water at 184 F, steam 210 F, run 15 mins.		26-21	-
11	A	⅔ full, water 172 F, worked in low 15 mins. standing 2 hours		0-0	680-720
12	B	⅔ full, water 90 F, 1-600 B, worked in low 15 mins. standing 2 hours		7-5	168-192
13	B	⅔ full, water 178 F, steam 210 F, worked in low ½ hr, standing 2½ hrs.		10-7	152-170
14	A	⅔ full, water 110 F, 1-600 B, worked in low ½ hr. standing 2½ hours		0-0	1440-
15	A	⅔ full, steam 208 F, water 174 F, worked in low ½ hr, standing 2½ hrs.	0-0	0-0	430-380
16	B	⅔ full, water 100 F, 1-1000 B, worked in low ½ hr, standing 2½ hrs.	0-0	3-10	480-530

* Temperature of water was taken at end of period, of steam at beginning by inserting thermometer in air vent in churn. The letter B refers to a chemical sterilizer labelled as containing 10 per cent available chlorine. The figures preceding B refer to dilution in water.

The 12 gallons of water from churn A were mould- and yeast-free twice in two trials (runs 3,8) when the churn had been one third full of a chemical solution. In one trial (run 10), when the churn had been one third full of heated water, it was not.

From churn A it was mould- and yeast-free twice in two trials (run 4, 14) when the churn had been two thirds full of a chemical solution, thre times in three trials (runs 1, 11, 15) when the churn had been two third full of heated water and once in one trial (run 2) when the churn had bee two thirds full of a heated solution of the chemical.

From churn B it was not mould- and yeast-free once in one trial (ru 9) when the churn had been one third full of a chemical solution and twic in two trials (runs 5, 6) when the churn had been one third full of heate water.

From churn B it was not mould- and yeast-free three times in thre trials (runs 7, 12, 16) when the churn had been two thirds full of a chemica solution and once in one trial (run 13) when the churn had been two third full of heated water.

In all cases however, the mould and yeast count per c.c. of water wa lower when the churn B had been two thirds full (runs 7, 12, 13, 16) tha when it had been one third full (runs 5, 6, 9).

When the sterilizing medium drawn from the churn was tested (run 5, 6, 15, 16) it was mould- and yeast-free four times, even though immediatel afterwards moulds and yeasts were worked from the churns into steril water in three of the trials (runs 5, 6, 16).

The 12 gallons of water from the churns were not sterile twelve times i twelve trials when both churns had been treated by the various methods give above for mould and yeast determinations. The counts ranged from 160 t 18,000 bacterial colonies per c.c., as obtained by standard methods. Man of the colonies were spreaders.

Series III. Experiments on the Efficiency of Various Chemica Sterilizers in Treating Churn Contaminated Water.

In these 14 experiments sterile water contaminated by the churn, or i 3 cases by mould and yeast types originally obtained from a churn, wa treated for 10 minutes by various dilutions of four commercial and one hom made chemical sterilizing solutions. One cubic centimetre of the treate water was diluted with 10 c.c. of sterile water and plated immediatel Sterilizer A was branded "an alkaline chloramine mixture ... germicidally active ingredients, 94%." B was labelled as containing 10 pe cent available chlorine and actually contained 8.13 grams of available chlorin per 100 c.c. of solution by an analysis made at the conclusion of the experi ments reported. Solution C was represented on the label as being a solutio of hypochlorites and chlorine. On analysis it contained 3.86 grams of avail able chlorine per 100 c.c. of solution. Sample D was a home-made sodiu hypochlorite disinfectant. It was made from sodium carbonate and chlorid of lime according to a formula suggested by the Committee on Bacteriologic Methods of the American Dairy Science Association (*3*). On analysis it wa found to contain 4.67 grams of available chlorine per 100 c.c. of solutio The character of solution E was not stated on the label of the container. I contained, on analysis, 2.23 grams of available chlorine per 100 c.c. o solution. The data are given in table 3.

TABLE 3. *Moulds and yeasts in churn contaminated water after treatment with various chemical sterilizers.*

Run	Colonies per c.c. in contaminated water.	Colonies per c.c. in portions of same water after treatment for 10 minutes.									
		Dil.	per c.c. A	Dil.	per c.c. B	Dil.	per c.c. C	Dil.	per c.c. D	Dil.	per c.c. E
1	37-29	1-960	28	1-160	0	1-160	0	-		-	
2	11-15	-		1-160	0	1-160	0	-		-	
3	281-279	1-960	47	1-160	2	-		-		-	
4	100-108	-		1-160	1	-		1-100	1	-	
				1-600	5						
5	241-243	1-960	69	1-160	0	1-160	0	1-200	0	-	
	-	-		1-600	0	1-600	0	-		-	
6	230-280	-		1-160	0	1-160	0	1-100	0	-	
7	50-56	1-960	38	1-160	0	1-160	0	1-100	0	-	
8	800-880	1-960	720	1-160	0	1-160	0	1-100	22	-	
9	400-425	1-960	402	1-160	0	1-160	0	1-100	0	-	
10	650-700	-		1-500	0	1-500	0	1-500	2	1-160	0
	-	-		1-1000	1	1-1000	0	1-1000	12	1-500	1
11	82-	-		1-500	0	1-1000	0	1-500	0	1-160	0
	-	-		1-1000	4	-		1-1000	4	1-500	0
12	71-	-		1-2000	14	-		1-1000	2	1-500	0
13	35-	-		1-750	0	1-750	0	1-750	0	1-500	0
	-	-		-		1-1000	0	1-1000	0	1-750	0
	-			-		-		-		1-1000	0
14	3-10	-		-		1-1000	0	-		1-1000	0

Yeast and mould colonies that came from churn contaminated water were picked from plates and used to contaminate the sterile water that was to be treated by the various chemicals in runs 8, 9 and 10. This was to make sure that the water had the contamination sought for.

The letters A, B, C, D and E refer to the different chemical sterilizers, and Dil. to dilution in water.

Sterilizer A did not make mould- and yeast-free six times out of six trials at a dilution of one teaspoon per gallon, which was the strongest solution recommended on the container. B was effective 12 times out of 17 trials using dilutions varying from 1 :160 to 1 :1000. In the five remaining trials the reduction amounted to 99, 99, 95, 99, and 95 per cent respectively, of the counts in the untreated water. In one trial a dilution of 1 :2000 reduced the count from 71 to 14 mould and yeast colonies per c.c. Solution C was effective 15 times in 15 trials using dilutions from 1 :160 to 1 :1000. D was effective 7 times in 13 trials using dilutions from 1 :100 to 1 :1000. In the six remaining trials the reduction amounted to 99, 97, 99, 98, 95, and 97 per cent respectively of the counts in the untreated water. Solution E was effective 9 times in 10 trials. In the remaining trial one mould colony was found in the 1 :500 dilution when the untreated water had counts of 650 and 700 in the duplicates.

Discussion

Moulds, yeasts and bacteria added to 12 gallons of sterile water worked in a churn in high gear for 10 minutes are significant since they demonstrate that the churn is not sterile. No doubt a portion of this contamination would be washed from the churn with the buttermilk and wash water. Moreover, the amount of cream being large, the dilution would be greater, so that the contamination per gram of butter would represent a smaller figure. If on the other hand the contamination originates chiefly from the workers, it is reasonable to assume that the contamination is not freed until working starts. Accordingly, the contamination in the butter would be considerable. The fact that the

strain on the workers is great when loaded with firm butter suggests the possible freeing of even more contamination than the working in high gear of the churn for 10 minutes with water.

The possibilities of chemical sterilization are suggested by the experiments of series 3, if the counts can be accepted as true indices of the germ-killing power of the various substances. In any plate count the result is influenced by the medium used. In these experiments the introduction of a small trace of chemical to the medium with the material plated may have introduced an inhibiting factor not common to the check. The results may mean that the chemical rendered inactive the moulds and yeasts present; they may mean that the moulds and yeasts found an unfavourable medium; or they may be the result of the combined effects of the two factors. Continued germicidal action affords a second consideration, so that the count at the end of a 48 hour period can not be accepted as indicative of the value of the solutions at the 10 minute exposure. The removal of the active reagent of the sterilizing solution at the end of the 10 minute exposure might prove the error of conclusions suggested in the results.

Heat destroys moulds and yeasts relatively easily. Bouska (*1*) states that 175°F. for 30 seconds kills spores of practically all species of moulds.

Mould- and yeast-free sterilizing solutions were drawn from the churns. Immediately after, rigorous working of the churns freed moulds and yeasts into sterile water, which suggests that these must have been lodged where the effects of the heat or chemical did not reach.

The greater sterilizing efficiency of both the hot water and chemical treatments when the churn was two thirds full suggests the greater possibility of moulds and yeasts being exposed to sterilizing conditions when the water covers the rolls.

Finally the fact that contamination can be worked out of the churn into sterile water suggests the importance of having the workers in motion during the sterilizing process.

Summary

1. Two churns regularly used for commercial use in a small way were found to discharge moulds and yeasts to 12 gallons of sterile water when worked rigorously, even after having been handled in what is recognized as the proper way.

2. Filling the churn two thirds full of sterilizing medium was found to render it more nearly mould- and yeast-free than filling it one third full.

3. Water heated to near boiling in a churn as a means of sterilizing was found to be mould- and yeast-free when removed from the churn.

4. Moulds and yeasts were worked from churns after extreme exposures to hot water and to chemicals.

5. Moulds and yeasts known to be present in water did not grow when plated in the recognized way after the water had been treated for 10 minutes by a chemical solution. Like results were obtained with three other solutions. They did grow after similar treatment by another chemical. The germicidal effects of the diluted chemical continuing after plating and the inhibiting effect of the chemical in the medium may be factors in the counts

obtained. Accordingly conclusions as to the efficiency of chemical solutions are not warranted.

6. It is suggested that the churn is not made mould- and yeast-free by extreme exposures because the sterilizing agent does not come in contact with the contamination.

7. The filling of the churn to above the rolls and the working of the churn during sterilization are recommended as important procedures in minimizing the germ content of a churn.

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REACTIONS OF WHEAT VARIETIES IN THE SEEDLING STAGE TO PHYSIOLOGIC FORMS OF *PUCCINIA GRAMINIS TRITICI*.*

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In 1926 the writers undertook to test the rust resistance of a number of wheat varieties and crosses to some of the physiologic forms of wheat stem rust prevalent in Canada. In a previous publication (*5*) they reported the reactions of twenty-three common wheat varieties and crosses, and six durum wheat varieties, to seven physiologic forms of *Puccinia graminis tritici* Erikss. and Henn. This work has been extended to include a number of other varieties and crosses. The rust reactions of these to twenty-two physiologic forms, including the seven forms above-mentioned, are presented in this paper. On the other hand, several of the less promising varieties tested in the earlier work have been dropped. Consequently the present paper includes all the information presented in the earlier publication, excepting the reactions of these few varieties. The results may be of interest to those engaged in developing rust resistant wheat varieties or otherwise engaged in rust investigations.

It should be pointed out that these reactions are the reactions of seedlings only, and they may or may not be identical with the reactions of the mature plants. The question of the relationship between seedling and mature-plant reactions has been discussed by several authors. Hursh (*4*) called attention to the difference between the rust reactions of Acme seedlings and the reactions of the same variety in the field, when approaching maturity. Goulden, Neatby and Welsh (*1, 2*), in a study of an H-44-24 × Marquis cross, showed that resistance in the mature plant stage was inherited independently of seedling resistance and concluded that the two types of resistance were therefore quite distinct. Harrington and Smith (*3*) state that "the use of seedling results as indications of after-heading reactions would have to depend upon the variety under consideration", but that in general there is a positive correlation between the seedling reaction and the degree of infection after heading. Popp (*6*) has shown that H-44-24 and Acme develop resistance to form 21 as they approach maturity.

From these results it appears that some wheat varieties may develop rust resistance, or increase their resistance progressively, as they mature. On the other hand, experimental evidence obtained at the Rust Research Laboratory points to the fact that varieties resistant in the seedling stage will normally remain resistant when mature.

Methods.

All the physiologic forms used in this work, with the exception of form 27, were isolated from rust material collected in Canada. Forms 15, 17, 21, 29, 34, 36, 38 and 49 have been of rather common occurrence for the

*Contribution from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

last three years. Forms 16, 19, 33, 35, 48, 53 and 57 have occurred but rarely and, so far, have been very limited in distribution.

The seedlings of the thirty-three wheat varieties tested were grown in four-inch pots. The first leaf of each seedling was hand inoculated with a pure culture of a physiologic form when the plants were about four inches high. Subsequent to inoculation, they were kept in moist chambers for forty-eight hours to allow the rust spores to germinate and cause infection. They were then removed to their respective booths in the greenhouse, and about fourteen days after inoculation, the rust reactions of the plants were recorded. Consecutive tests were carried out for each variety, at intervals, for a period of over a year. This procedure enabled the writers to record the reactions of the various varieties at different times of the year, for a variety may vary somewhat from time to time in its reaction to a particular physiologic form, due to changes in environmental conditions such as light, temperature or humidity. In table 1 only the average of all the reactions for each variety is indicated. For some of the varieties a considerable number of tests had to be made although for others a few tests only were required to establish a satisfactory mean.

Explanation of Terms in Table.

The following symbols, adapted from Stakman and Levine (*7*), are used in the table to indicate the types and degrees of infection on the varieties tested.

Types of Infection

0 indicates that plants are immune; no uredinia are developed and hypersensitive flecks are usually not present.

0; Plants are immune, no uredinia are developed, but hypersensitive flecks occur. The rust organism has entered the host tissues but the host is so uncongenial that development soon ceases.

1 Plants are very resistant. Uredinia are very small and surrounded by sharp, hypersensitive, necrotic areas.

2 Plants are moderately resistant. The uredinia are small to medium in size; hypersensitive areas present in the form of necrotic halos, surrounding green islands in the centre of which the uredinia are usually located.

3 Plants are moderately susceptible. The uredinia are of medium size, sometimes, but infrequently coalescing. Necrosis and hypersensitiveness are absent but chlorotic areas may surround the uredinia.

4 Plants are very susceptible. The uredinia are large and usually coalesce to form large irregular pustules. Hypersensitive and necrotic areas are absent but chlorotic areas may surround the pustules.

x Plants are heterogeneous in their reaction. All the above reactions may occur together on the same leaf. Certain physiologic forms produce this reaction on some varieties, especially on some of the durum wheats.

Degrees of Infection

(=) Trace. Uredinia are few and small and rust development poor.
(—) Slight. Rust development slightly better than "Trace".
(±) Degree of infection moderate for its type of infection.
(+) Degree of infection considerable. Infection above the normal of its type.
(++) Degree of infection abundant. The development of rust much above the normal for its type of infection.
(±c) Degree of infection moderate for its type, but the pustules are accompanied by sharp chlorosis.
(±n) Degree of infection moderate for its type, but the pustules are accompanied by necrosis.

TABLE 1. *The mean host reactions of 33 wheat varieties and hybrid strains in the seedling stage to 22 physiologic forms of Puccinia graminis tritici Erikss. and Henn.*

Varieties Tested	PHYSIOLOGIC FORMS 9	14	15	16	17	19	21	27	29	30	32	33	34	35	36	38	48	49	50	52	53	57
Little Club, R.L. 223	4	4+	4	4—	4	4	4	4=	4	4	4	4+	4+	4	4	4	4+	4	4+	4	4	4
Chul, R.L. 543	4	4	4+	4+	4	3=c	4+	2+	4+	4+	4	4+	4	4+	4+	3±	4	4+	4+	4+	4+	4+
Garnet, R.L. 15	4—	4—	4	4	4	4	4	4	4	4	3+	4	4	4	4	4	4	4	4+	4	4	4
Ruby, R.L. 12	4—	2+	3+	3	4—	3—	4+	3+	4+	4+	4	3	4	3+	4+	3+	3—	4	3	4	3+	4—
682-B, R.L. 88	4—	4—	4—	4	4—	4—	4—	3+	4	4—	3	3	4	3+	3	4—	3±	4	4—	3=	3±	4
Pelissier, R.L. 145	4	4	4	4	4	3+	4—	4—	4—	4—	4—	4—	4—	4—	4—	4	4	4	4	3+	4	4
Acme, R.L. 220	3++	3++	3++	4=	3++	3++	3++	3++	x+	x+	x+	3++	3++	3++	3++	x++	4—	3+	x±	4	4	3+
*Kubanka, R.L. 218	4=	3++	3++	3+	3++	3++	4=	4=	x	x	x	4=	4=	3+	x	x+	x+	x=	x=	3++	4	3+
Monad, R.L. 205	3+	3±	3±	4	4—	3	3+	4	3±	3—	x—	4	3+	3	3+	4	4	3+	4—	4—	4—	4
Marquis, R.L. 222	4—	2—	4—	2=	4—	2—	4	2	4—	4	4=	2	4—	4=	4	2=	1	4—	2+	4	2±	4
Parker's, R.L. 71	3+	1	3±n	2+	3+	1	3+	2±	4—	4—	4	1	4—	3+	4—	2—	2—	3+	3-c	4—	1+	4—
Power, R.L. 202	4—	2	4	3-c	4—	3-c	4	2+	4	4	4	2+	4	3+	4	3±c	2	4	3±c	4	2	4+
Quality, R.L. 133	4—	2	4	3—	4—	2+	3+	2±	4	4	3+	2+	4—	4	3+	2	2—	4	3±	3+	1+	4
Renfrew, R.L. 135	4	2+	4—	3	4—	2	4	2±	4	4—	4—	2+	4	4	4	3±c	2	4	2+	3+	2+	4+
Reward, R.L. 79	3+	2+	4—	2+	3	3±c	4—	2+	3+	4	3	2+	4—	3+	3+	2+	3c	3+	3±	3+	2+	4
Supreme, R.L. 77	4	2—	4	3	4	1+	4	2±	4	4	4	2	4	4—	4	2	2—	4—	3—	4	1+	4
*Marquillo, R.L. 132	3±	0;	3±	3±	3±c	1	2±	1	0;	3±c	3—	0;	3±c	4—	3±	2±	2±	2+	3+	3±c	2—	3±c
Axminster, R.L. 75	3+	3±n	3+	3+	3±n	3±	3±	2+	4	4—	4+	3±n	4—	4—	4—	3±n	3±n	4—	4	3±n	3±n	4—
Kota, R.L. 221	3++	1++	3++	1	3+	3—	3++	0	3	3++	3+	1+	4=	0;	3++	3—	1+	4=	2+	4	1	3+
Ceres, R.L. 127	3+	2	3	3—	3+	3—	3+	0;	3—	3+	3—	0;	4—	0;	4—	3±c	0;	3+	3	3±	1	4
N.D., 1656, R.L. 126	3+	1	3—	3=	3±	3±	3+	0;	3—	3+	2+	0;	3+	0;	4—	2+	0;	3+	3—	3±	0;	4
Black Persian, R.L. 388	1+	1	2±	2±	2±	2±	2±	2	2±	2±	2±	2	2±	0;	2++	2+	2	2±	2++	2+	2—	2++
Webster, R.L. 365	3—	3-c	3—	3—	3=	3—	3—	2	3—	3—	3	3—	3—	3=	3—	3=	3—	3—	3—	3—	3—	3
Sev. × Dick., R.L. 368	3—	3=	3—	3-c	3—	3—	3—	2±	3—	3—	2+	3—	3—	3=	3+	3±	3—	3	3-c	3—	2±	3±c
Hope, R.L. 209	3—	1+	3±	2—	3	2	3+	0;	3±	3+	3	1	3+	1	1	1+	1+	0;	0;	2—	2	1
H-44-24, R.L. 229	3±	2	3±	3±c	3±	1+	3±c	0;	3c	3±	3c	1	3±c	1	1	2+	3±c	1	1	1+	2+	2
Kanred	0	1—	4=	0	0	0;	0	0	0	0	4=	4	4—	3+	4—	4—	0;	0	0;	4—	0	0
D.C. 806-6, R.L. 381	0;	0;	2	0	0;	0	0	0	0	0	3—	0;	1	2±	3—	2+	0	0	0;	3±c	0;	0;
D.C. 825-2, R.L. 379	0;	1	2	0;	0;	0;	0;	0	0;	0;	3	0;	1	3±c	3±	2	0;	0;	0;	3±c	0;	0
*Pentad, R.L. 203	3—	3±	2±	3+	3±c	3±c	3±	4	0;	0;	0;	x—	4	x±	0;	1±	0;	x	1+	0;	3+	3+
*Iumillo, R.L. 7	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;
Vernal, R.L. 216	4=	1=	4=	1=	1=	0;	0;	4=	1—	4=	1=	1—	0;	0;	0;	1=	1=	0;	0;	4+	3±	3
Khapli, R.L. 215	1—	0;	1=	1	1=	1=	1=	1+	1—	1	1—	1	1=	1	1—	1+	1+	1=	0;	1—	1	1

R.L. numbers represent the accession numbers of the plant breeding department of the Dominion Rust Research Laboratory, at Winnipeg.

[illegible] as indicated by their rust reaction.

Origin of Varieties Tested

Acme, R.L. 220 (C.I. 5284). A selection from Kubanka made by Prof. M. Champlin at Brookings, South Dakota.

Axminster, R.L. 75. Developed by Mr. Samuel Larcombe, of Birtle, Manitoba.

Black Persian, R.L. 388. A Persian emmer obtained from Dr. W. P. Thompson, University of Saskatchewan, Saskatoon, Sask., and originally secured by him from Dr. J. A. Clark of the U.S.D.A.

Ceres, R.L. 127 (C.I. 6900). Formerly known as N.D. 1658. A selection from a Marquis × Kota cross made by Dr. L. R. Waldron of the North Dakota Agricultural Experiment Station.

Chul, R.L. 543. Introduced into the United States in 1902, from Russian Turkestan by the United States Department of Agriculture through Dr. E. A. Bessey.

Double Cross, 806-6, R.L. 381. A selection from a cross between Marquis × Iumillo and Marquis × Kanred. Produced by Dr. H. K. Hayes of the Minnesota Agricultural Experiment Station, St. Paul, Minn.

Double Cross 825-2, R.L. 379. Same origin as above.

Garnet, R.L. 15 (Ott. 652). From a cross made in 1905 by Dr. Chas. E. Saunders between Preston A and Riga M.

Hope, R.L. 209. A selection from a cross between Marquis and Yaraslov Emmer made by Mr. H. S. MacFadden, Webster, South Dakota.

Iumillo, R.L. 7. A selection from Iumillo made by Prof. W. Wiener at the Manitoba Agricultural College, Winnipeg, Man.

Kanred, (C.I. 5146). A selection from a Crimean variety made by Dr. H. F. Roberts at the Kansas Agricultural Experiment Station.

Khapli, R.L. 215, (C.I. 4013). An emmer, obtained from India, in 1908, by the United States Department of Agriculture.

Kota, R.L. 221 (C.I. 5878). Obtained from Russia by Prof. H. L. Bolley of the North Dakota Agricultural College, in 1903, as a mixture in a sample of durum wheat. In 1919 it was named Kota by Waldron and Clark.

Kubanka, R.L. 218 (C.I. 2094). Introduced from Russia into the United States by Dr. M. A. Carleton.

Little Club, R.L. 223 (C.I. 4066). Origin undetermined, but it is believed to have been introduced into the United States from Chile.

MacFadden's Emmer (H-44-24), R.L. 229. Developed from a Marquis × Yaraslov Emmer cross by Mr. H. S. MacFadden, Webster, South Dakota.

Marquillo, R.L. 132 (Minn. II-15-44). Developed from a Marquis × Iumillo cross made by Dr. H. K. Hayes and Dr. O. Aamodt, at the Minnesota Agricultural Experiment Station, St. Paul, Minn.

Marquis, R.L. 222 (C.I. 3641). A selection made by Dr. Chas. E. Saunders in 1904 from Markham, a cross between Hard Red Calcutta and Red Fife, made in 1892 by Dr. A. P. Saunders.

Monad, R.L. 205, (D-1). Introduced from Russia, in 1903, by Dr. H. L. Bolley of the North Dakota Agricultural College.

N.D. 1656, R.L. 126. A selection from a Marquis × Kota cross made by Dr. L. R. Waldron of the North Dakota Agricultural Experiment Station.

Ottawa 682-B, R.L. 88. From a cross between Red Fife and Smooth Spelt. Obtained from the Central Experimental Farm, Ottawa, Ont.

Parker's, R.L. 71. A selection made by Mr. J. L. Parker, Gilbert Plains, Man.

Pelissier, R.L. 145 (Sask. 41). A Saskatchewan selection. The variety Pelissier was introduced from Algeria by W. T. Swingle of the United States Department of Agriculture in 1900.

Pentad, R.L. 203 (D-5). Introduced from Russia, in 1903, by Dr. H. L. Bolley of the North Dakota Agricultural College.

Power, R.L. 202 (C.I. 3697). A selection of Red Fife wheat made at the North Dakota Agricultural Experiment Station in 1892.

Quality, R.L. 133. Developed by Luther Burbank of Santa Rosa, California.

Renfrew, R.L. 135. A selection from Marquis made by Prof. G. H. Cutler at the University of Alberta, Edmonton, Alta. This variety is believed to be a natural cross between Marquis and Red Fife.

Reward, R.L. 79 (Ott. 928). A selection from a cross made by Dr. Chas. E. Saunders in 1912 between Marquis and Prelude.

Ruby, R.L. 12 (Ott. 623). A cross between Downy Riga G. and Red Fife D, made by Dr. Chas. E. Saunders in 1905.

Sevier × Dicklow, R.L. 368 (G. 149). A cross made by Dr. Geo. Stewart, Department of Agronomy, Agricultural College, Utah.

Supreme, R.L. 77. A selection from Red Bobs made by Dr. Seager Wheeler, Rosthern, Sask.

Webster, R.L. 365 (C.I. 3780). Imported under the name Mongolian. Named Webster at the Minnesota Agricultural Experiment Station.

Vernal, R.L. 216 (C.I. 3686). An emmer wheat dating from prehistoric times. Nothing is known about its introduction into America, but it appears to have been grown in the Great Plains region as early as 1875.

Discussion.

As it was only possible to test a limited number of varieties, the particular ones included in table 1 are representative of the following classes: (1) Those which are either commonly grown in Western Canada or are now being introduced among farmers, such as Marquis, Garnet, Ruby, Quality, Axminster, Renfrew and Reward. (2) Those which have been produced recently in attempts to develop rust resistant wheat of economic quality, such as Ceres, N.D. 1656, D.C. 806-6 and 825-2, Marquillo and Webster. (3) Those which have been used or may be used as resistant parents in crosses made with the object of developing rust resistant wheat varieties, such as Kanred, Kota, H-44-24, Black Persian, the durum wheats, and the emmers, Vernal and Khapli.

The varieties are arranged in the table in groups, each group having something in common with respect to its rust reactions to the forms used. There is, first, a group of varieties which have little or no resistance to any of the physiologic forms. This includes Little Club, Chul, Garnet, Ruby, 682-B and Pelissier. Acme, Kubanka and Monad do not seem to possess much resistance, but in the case of Acme, as has been pointed out, the seedling reaction cannot be considered a criterion of its rust resistance at maturity.

The varieties of the second group resemble Marquis so closely in their reactions that one might say that they possess the Marquis type of rust reaction. This group includes Parker's, Power, Quality, Renfrew, Reward and Supreme. Axminster, likewise, resembles Marquis in this respect, except that it produces a reaction designated as $(3 \pm n)$ to forms which give a clear cut (1) or (2) type on Marquis. Marquillo, also, resembles Marquis in its reaction to the majority of the forms, but possesses high resistance to forms 21 and 29, forms to which Marquis is susceptible.

The remaining varieties in the table do not fall into well-defined groups, but certain of them have similarities in their reactions. Ceres and N.D. 1656, as might be expected, resemble Kota in their reactions since Kota is one of the parents.

Sevier × Dicklow, Webster, and Black Persian are rather remarkable for their uniform reactions to all the physiologic forms. Black Persian is decidedly resistant to all the forms, while the other two are near the border line between resistance and susceptibility.

Hope and H-44-24 are two closely related varieties which are very similar in their behaviour. They are highly resistant to most of the forms,

but even where the reaction is of a susceptible type, the pustules are accompanied by a sharp chlorosis. This is especially true of H-44-24.

The double crosses, 806-6 and 825-2, are immune to the same forms as the Kanred parent, but they are likewise practically immune to forms 33 and 34, forms to which Kanred is susceptible. They do not appear to be thoroughly susceptible to any of the physiologic forms.

Iumillo is the only variety immune to all of the forms, while Khapli is highly resistant to all, rather than immune.

Many other varieties might have been included in these tests, but owing to the great amount of work involved in testing a variety, it was not found possible to include them. Among those reported on, however, are many of the most promising of the rust-resistant wheats produced in recent years.

It should perhaps be stated that not all of the physiologic forms known in Canada were included in these tests. The forms used, however, were sufficiently numerous and diverse in character to give a fairly accurate idea of the resistance or susceptibility of each wheat variety. These forms, also, may be considered representative of stem rust in Canada, for they embrace all those which have occurred in any appreciable amount within the last few years.

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CORRELATED INHERITANCE OF GLUME COLOUR, BARBING OF AWNS AND LENGTH OF RACHILLA HAIRS IN BARLEY.*

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Introduction.

A number of genetic studies have been made with barley in recent years. This is partly because of the commercial importance of the crop, and partly because of the many distinct heritable characters of barley plants. Some of the characters have been shown to be inherited in a simple Mendelian manner, but with some others the mode of inheritance is much more complex. In general, investigators are in agreement with regard to the inheritance of the simple characters, but agreement is not complete for all characters worked with, and very little work has been done in order to establish definite linkage groups.

Most commercial varieties of barley have rather rough awns. This makes them rather disagreeable to handle, as well as a source of danger to certain kinds of live stock, since the rough awns may easily become buried in the throat tissues of the animals. Harlan and Anthony (*3*) have shown that barley spikes with the awns clipped do not develop normally and, further, that awnless and hooded varieties of barley do not yield as well as the awned varieties. The awn therefore appears to be an important physiological organ. Hayes and Wilcox (*6*) made a comparison of the transpiration of spikes of rough and smooth-awned varieties and found that smooth-awned varieties have no physiological limitation when compared with standard rough-awned sorts. Since the presence of awns is apparently correlated with high yield, it would be of great practical importance to obtain smooth-awned varieties which would be equal to the rough-awned varieties in all characters of agronomic value. It was chiefly with the idea of bringing into existence smooth-awned strains suited to Manitoba conditions that the work of barley crossing was undertaken by the writer and, incidentally, to learn something about the genetic relationship of some of the characters concerned. The characters studied in this paper are black *versus* white glume, rough *versus* smooth awn and long-haired *versus* short-haired rachilla.

Review of Literature.

In this study no attempt has been made to make an extensive review of the literature on barley inheritance. Attention, however, is drawn to previous work that has a direct bearing on this subject.

Rough versus Smooth Awn: Barley varieties are classified as rough or smooth according to the presence or absence of serrations on the awns. Most varieties are serrated, having teeth on the awns extending from the base to the tip, but a few that are classified as smooth, and first investigated by Vavilov (*9*), were found to have a few short barbs near the tip of the

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awn. Harlan (*2*), who was the first to make a cross between a rough and a smooth-awned variety, found a single factor difference between rough awn and smooth, with rough dominant. Vavilov (*9*) obtained smooth-awned types in the F_2 generation from crosses in which both parents were rough-awned and concludes that smooth-awned varieties probably arose through hybridization.

Crosses have been made between rough and smooth-awned varieties at the Minnesota Experiment Station. Hayes *et al* (*5*) report that all F_1 plants had rough awns, while the F_2 generation segregated into rough and smooth-awned plants, in an approximate 3:1 ratio. Considerable variation in degree of roughness was found between individual plants in the smooth-awned class. An awn index was obtained by dividing the total length of the awn by the length of the tip upon which teeth were found. The larger the index number, the smoother the awn, and vice versa. Third generation lines from F_2 plants varied in their breeding behaviour. All F_2 smooth-awned plants bred true for the smooth-awned condition in F_3 but some of the F_3 lines had all plants of either high or low awn indices, while others produced both. Some of the F_3 lines, classified as rough in F_2, bred true for roughness while others segregated into rough and smooth, giving rise to all forms found in F_2. The results are explained on the basis of one main factor difference between rough and smooth awn.

Griffee (*1*) divided all F_2 plants into three recognizable phenotypes based on an arbitrary awn index division, viz., rough, intermediate-smooth and smooth. He reports a 2-factor difference for roughness. The factor R produces rough awn, while the factor S is hypostatic to R and in the absence of R produces intermediate-smooth awn. The double recessive, *rr ss,* produces smooth awn. He obtained the three phenotypes mentioned in a 12:3:1 ratio.

Colour in Glumes: Hayes *et al* (*5*), Griffee (*1*), Robertson (*10*) and Von Ubisch (*8*) have reported a single factor difference between black and white glume with black fully dominant.

Long versus short-haired rachilla: The rachilla is the prolongation of the primary axis of the spikelet, and is hidden in the groove on the ventral side of the kernel. In some varieties the rachilla is beset with long hairs, sometimes quite bristly, while in others the hair is short and woolly. Von Ubisch (*8*), Hor (*7*) and Robertson (*10*) have all reported a monohybrid mode of inheritance when these two forms are crossed, with the long-hair character dominant.

Linkage Relations: Hor (*7*) reports a definite linkage between the allelomorphic pairs rough *versus* smooth awn and black *versus* white glume, with a cross-over percentage of 41.48 ± 5.45. Hayes *et al* (*5*), who probably worked with different varieties, found these characters assorted independently. The existence of duplicate factors for either rough awn or black glume colour is a plausible explanation for this discrepancy in results. Hor (*7*) furthermore reports linkage relations between black and white glume, rough and smooth awn and long and short-haired rachilla, the cross-over percentage

between the last mentioned factor pairs being 28.70 ± 3.43 in the case of repulsion and 34.54 ± 2.89 when coupling was exhibited. In this linkage group the most probable sequence of the genes is BRL, the distance between R and L being considerably shorter than between B and R, but the assignment of definite distances between these genes is not attempted.

Robertson (*10*) has done extensive work in determining the linkage relations of the factor pairs for glume colour and length of rachilla hairs, and concludes that these are independently inherited.

Material and Methods: The varieties used in this study, Bearer, Chinese and Lion, belong to the species *vulgare* and were known to be homozygous with respect to the characters under investigation. Bearer and Chinese are of the Manchurian type. They have rough awns, white glumes and short-haired rachillas. Lion has black glumes and long-haired rachillas and is classed as a smooth-awned variety, though it has a few short barbs near the tips of the awns. This barbing may extend from ¼ inch to ¾ inches from the tip, and is probably a fluctuating variation.

The results given here are from the crosses Bearer × Lion and Chinese × Lion, made at the Dominion Experimental Farm, Brandon, Man., in 1924 and 1925, respectively. An F_3 population of the former and an F_2 of the latter were available for the study. The hybrid progenies were grown in the plant breeding nursery and the necessary field notes taken. In the case of the Bearer × Lion cross no counts were made on the segregation of long *versus* short-haired rachilla in the F_2 population as it was not the original intention to study this character. Counts for the segregation of these characters were, however, obtained in the F_3 lines of the Bearer × Lion cross in 1927, as well as the F_2 material of the Chinese × Lion cross.

Experimental results: In the presentation of the experimental results the inheritance of the characters under investigation are first considered separately. Afterwards the results are discussed from the standpoint of correlated inheritance.

Black versus white glumes: Glumes of the F_1 plants in the crosses Bearer × Lion and Chinese × Lion appear to be just as black as those of the Lion parent, indicating complete dominance. In the second generation black and white glumed plants are obtained in an approximate 3:1 ratio (see table 1). The black colour does not appear until just before maturity, which makes it very difficult to classify immature plants correctly. The F_2 plants of the Bearer × Lion were allowed to become fully mature before harvesting in 1926. As expected, all white F_2 plants bred true for the white glume colour, 65 F_3 lines being grown. Out of 26 black plants selected for propagation, 10 bred true for black glume colour, while 16 plants segregated for black and white. The deviation from the expected 1:2 ratio is 1.3 while the probable error is 1.5. Summing the 16 F_3 lines (table 2) a deviation of 25.5 is obtained and a probable error of 14.2. A deviation as large as this may be expected to occur due to chance alone, at least 25.5 times in 100 trials. Apparently black and white differ by a single factor.

TABLE 1. *Distribution of plants for glume colour in the F_2 generation of the crosses Bearer × Lion and Chinese × Lion.*

Year grown	F_2 PLANTS Black glumed	White glumed	Total	Cross
1926	837	275	1112 observed	Bearer × Lion
	834	278	1112 calculated	
		3	Deviation	
		9.74	Probable error	
1927	1581	557	2138 observed	Chinese × Lion
	1603.5	534.5	2138 calculated	
		22.5	Deviation	
		13.5	Probable error	

TABLE 2. *Distribution in 1927 of plants in 16 F_3 lines which segregated for glume colour; cross Bearer × Lion.*

F_2 plant number	Black-glumed	White-glumed	Total	
C-24-113	142	49	191	
116	156	62	218	
117	53	22	75	
119	84	28	112	
120	98	31	129	
121	136	46	182	
124	113	39	152	
126	97	36	133	
127	142	48	190	
129	80	29	109	
131	126	42	168	
132	84	32	116	
133	161	53	214	
134	64	22	86	
136	105	38	143	
137	108	40	148	
	1749	617	2366	Total observed
	1774.5	591.5	2366	Calculated on 3:1 basis
		25.5	Deviation	
		14.2	Probable error	
		Dev./P.E.=1.8		

Long and short-haired rachilla: The rachilla presents a pair of differentiating characters which can easily be distinguished and hence they are of great taxonomic value. The short-haired rachilla is always covered with short, fine, woolly hairs but the long-haired rachilla may have either long, bristly or long, fine hairs. In table 3, by combining in one class all plants with long-haired rachillas, whether bristly or fine, an almost perfect 3:1 ratio was obtained, indicating a simple monohybrid inheritance, with the long-haired condition dominant.

TABLE 3. *Distribution of plants for length of rachilla hairs in the F_2 generation of the cross Chinese × Lion 1927.*

Long-haired rachilla	Short-haired rachilla	Total
1609	529	2138 observed
1603.5	534.5	2138 calculated
	5.5 Deviation	
	13.5 Probable error	

Rough versus smooth awn: The crosses Bearer × Lion and Chinese × Lion gave F_1 plants with awns which appeared to be as rough as those of the rough parent. The awns of Bearer and Chinese differ in degree of roughness, the latter being considerably more scabrous. This difference was quite apparent in the F_1 of both crosses. The F_2 plants were easily classified into 4 groups (see table 4). The rough and intermediate-rough classes have barbs on the entire length of the awn, but the awns of the latter class are not nearly as scabrous. When heads of these phenotypes were examined in sunlight, and when held at the correct distance from the eye to be properly focussed, the difference could be easily discerned.

The intermediate-smooth class has awns just as smooth at the base as those of the smooth class. The barbing starts near the centre of the awn and extends to the tip, whereas in the smooth class the barbing seldom extends more than ¾ inch from the tip. In both cases the barbs are relatively short as compared with the rougher classes. There is some variation in the barbing on the plants within each of these phenotypes, which is perhaps natural since the rough class consists of 4 genotypes while each of the intermediate classes consists of 2 genotypes. The smooth class consists of but one genotype. The slight differences in the barbing of plants within this class are no doubt fluctuating variations due to environment.

TABLE 4. *Distribution of plants for awn barbing in the F_2 generations of the crosses Bearer × Lion and Chinese × Lion.*

Year grown	CHARACTER OF AWN Rough	Int.-Rough	Int.-Smooth	Smooth	Total	Cross
1926	381	120	117	40	658 observed	Bearer × Lion
	370	123.3	123.3	41.1	658 calculated on 9:3:3:1 basis X^2=.52 P=very high	
1927	1197	414	391	136	2138 observed	
	1203.3	401.1	401.1	133.7	2138 calculated on 9:3:3:1 basis X^2=.73 P=very high	Chinese × Lion

Assumed genotypes per 16—
1RRSS 1RRss 1rrSS 1rrss
2RrSS 2Rrss 2rrSs
2RRSs
4RrSs

The observed distribution of F_2 plants, table 4, was very close to the theoretical 9:3:3:1 ratio. The application of Harris' goodness of fit test gives an X^2 in either case less than unity and a very high P value. This indicates a 2-factor difference for roughness of awn, and shows that these factors are cumulative in effect. The factor R, either single or in duplicate, and in the absence of S, produces the intermediate rough condition and similarly the factor S, in the absence of R, produces the intermediate smooth condition. The factor R is the main factor and produces a greater effect than S, but both are required, either singly or in duplicate, to produce the fully rough class. The smooth class is the double recessive and has the genetic constitution *rrss*.

The results obtained by the writer differ from those obtained by Griffee (*1*) only in the fact that 4 phenotypes have been recognized instead of 3.

Griffee considers the factor R alone capable of producing the fully rough condition and believes that the effect of S is masked by R making the factor S hypostatic to R. After two years' experience the writer is convinced that it is relatively easy to separate the intermediate-rough class from the fully rough class and that there is a wide line of demarcation between the two intermediate classes. In view of the fact that these factors are cumulative in effect, the writer has recently attempted to separate the genotypes within each of these classes, but with what degree of success is not yet known. A careful examination of a large number of plants in the smooth class failed to reveal a single plant that had entirely smooth awns. The slight barbing, near the tip of the awns in the smooth-awned class may be due to a third factor, the effect of which is entirely masked in the rough as well as in the intermediate classes. If a 3-factor hypothesis for roughness of awn is correct, the results show that the varieties Bearer and Lion are homozygous for the third factor.

The breeding behaviour of the F_3 lines affords sufficient proof of the 2-factor hypothesis and shows that the factors R and S are cumulative in effect. Eight out of twelve F_2 plants in the Bearer × Lion cross selected for propagation, and which were classified as intermediate rough (see table 6), segregated in F_3 in a 3:1 ratio for intermediate-rough and smooth awn, while 4 plants bred true for the intermediate-rough condition.

TABLE 5. *Distribution in 1927 of plants for awn barbing in 11 F_3 lines from F_2 plants classified as rough; cross Bearer × Lion.*

F_2 Plant number	CHARACTER OF AWN: Rough	Intermediate rough	Intermediate smooth	Smooth	Total
C-24-51	72	24	22	14	132
68	82	24	22	7	135
72	146	40	42	15	243
77	100	25	27	7	159
79	83	24	20	7	134
117	41	13	14	7	75
120	77	23	20	9	129
121	108	32	32	10	182
124	87	28	29	8	152
130	98	31	31	10	170
131	89	34	35	12	170
	983	298	294	106	1681 observed
	945	315	315	105	1680 calculated on 9:3:3:1 basis
		X^2=3.84		P=.2824	

TABLE 6. *Distribution of plants for awn barbing in 8 F_3 families of Bearer × Lion from plants classified as intermediate rough in F_2.*

F_2 Plant number	CHARACTER OF AWN: Intermediate Rough	Smooth	Total
C-24-46	63	21	84
48	61	21	82
94	84	28	112
99	88	30	118
106	89	31	120
123	97	34	131
133	159	55	214
136	105	38	143
	746	258	1004 observed
	753	251	1004 calculated on 3:1 basis
		7	Deviation
		9.25	Probable error

TABLE 7. *Distribution of plants in 19 F_3 families from F_2 plants classified as intermediate-smooth and which segregated for character of awn in 1927; cross Bearer × Lion.*

F_2 Plant number	CHARACTER OF AWN Intermediate smooth	Smooth	Total
C-24-42	101	34	135
44	199	61	260
47	96	31	127
55	155	53	208
59	63	22	85
80	135	50	185
83	95	32	127
84	171	62	233
85	82	29	111
88	90	30	120
92	116	40	156
96	49	16	65
104	64	22	86
105	62	21	83
107	85	30	115
132	88	28	116
134	64	22	86
135	105	34	139
137	109	38	147
	1929	655	2584 observed
	1938	646	2584 calculated on 3:1 basis
		9	Deviation
		14.8	Probable error

Nineteen plants which had been classified as intermediate-smooth in F_2 (see table 7) segregated in an approximate 3:1 ratio for intermediate-smooth and smooth awn. The deviation from the theoretical ratio is slightly less than the probable error so that a deviation as large as this may be expected to occur at least 50 times out of 100 trials. The number of plants which bred true for intermediate-smooth awn was slightly in excess of the theoretical 1:2 ratio.

TABLE 8. *Distribution of plants in 7 F_3 families for the characters rough awn and intermediate-rough awn from plants classified as rough in the F_2 from the cross Bearer × Lion,* 1927.

F_2 plant number	CHARACTER OF AWN Rough	Intermediate rough	Total
C-24-70	88	28	116
75	145	46	191
76	75	25	100
113	144	47	191
119	85	27	112
126	100	33	133
127	136	47	183
	773	253	1026 observed
	769.5	256.5	1026 calculated on 3:1 basis
		3.5	Deviation
		9.35	Probable error

Four out of 22 F_2 plants classified as rough, bred true for the rough awn condition. Seven plants segregated for rough awn and intermediate-rough awn in a 3:1 ratio (table 8) while 11 plants (table 5) segregated into the 4 awn classes and would therefore have the same genetic constitution as F_1 plants of the Bearer × Lion cross. On the basis of random sampling,

2/9 of the total number of rough plants should have segregated in a 3:1 ratio for rough and intermediate-smooth awn. Not one of the plants gave this segregation. No doubt a much larger number of plants would have to be selected to be reasonably sure of having all genotypic classes represented. Not one of the F_3 lines segregated for rough and smooth awn in a 3:1 ratio, nor was this to be expected on the 2-factor hypothesis.

Independent Inheritance.

Black glumes versus White and long-haired rachilla versus short: In the crosses Chinese × Lion and Bearer × Lion, the character pair, black versus white glume, was shown to be differentiated by a single factor pair. The same was shown to be the case for the character pair, long-haired versus short-haired rachilla. The relation of these allelomorphic pairs is shown in tables 9 and 10. In testing for goodness of fit, the theoretical 9:3:3:1 ratio was not used, but instead the black and white glumed classes were considered separately. In both tables 9 and 10 the white glumed plants are too numerous, probably due to being wrongly classified, and any deviation from a 3:1 ratio between black and white glumed plants should in no way affect the calculation of linkage relation. On this basis the F_2 population in table 9 shows independent assortment for the factor pairs involved. The distribution of 802 plants representing 6 F_3 families (table 10) which segregated both for glume colour, and rachilla length, gives further proof of the independent inheritance of these factor pairs. In fact, when the results from the 6 lines are summated the $X^2<1$, which indicates a very good fit.

Table 9. *Distribution of F_2 plants for the characters long versus short-haired rachilla and black glume versus white; cross Chinese × Lion, 1927*

Black glumed		White glumed		
Long-haired rachilla	short-haired rachilla	Long-haired rachilla	short-haired rachilla	Total
1179	402	430	127	2138 observed.
1185.7	395.3	417.7	139.3	2138 calculated on 3:1 basis for 2 groups.
		$X^2=1.6$		P=.6640

Table 10. *Distribution of plants in 6 F_3 families for the characters glume colour and length of rachilla hairs; cross Bearer × Lion, 1927.*

No. of F_2 plant	Black glumed		White glumed		Total
	Long-haired rachilla	short-haired	long-haired rachilla	short-haired rachilla	
C-24-117	41	12	15	7	75
120	69	29	25	6	129
121	92	34	35	11	172
123	70	26	26	9	131
124	89	24	39	10	162
126	74	23	27	9	133
Total all families	435	148	167	52	802 observed
	437.3	145.7	164.3	54.7	802 calculated on 3:1 basis for each group
		X^2=less than 1		P=good fit	

Black Glumes Versus White and Rough Awns Versus Smooth: From the distribution of F_2 plants, table 11, it is evident that the factor pairs black *versus* white glume and rough *versus* smooth awn are independent of each

other in inheritance. A deviation as large or larger than the one obtained would be expected 87 times in 100 trials. The F_3 data in tables 12 and 13 give further proof of the independent assortment of the factor pairs involved. The results obtained are in complete agreement with those obtained by Hayes *et al* (*5*) and Griffee (*1*).

TABLE 11. *Distribution of F_2 plants for glume colour and awning, cross Chinese × Lion, 1927.*

Black glumed				White glumed				
Rough	Int Rough	Int. Smooth	Smooth	Rough	Int. Rough	Int. Smooth	Smooth	Total
894	302	286	99	303	112	105	37	2138 observed
889.4	296.4	296.4	98.8	315.6	105.2	105.2	35	2138 calculated on basis of 2 groups of 4 classes each

X^2=1.54 P=.8759

TABLE 12. *Distribution of plants in 5 F_3 families which segregated for glume colour and character of awn, cross Bearer × Lion, 1927.*

Family	Black-glumed				White-glumed				
	Rough	Int. Rough	Int. Smooth	Smooth	Rough	Int. Rough	Int. Smooth	Smooth	Total
C-24-117	29	9	10	5	12	4	4	2	75
120	60	18	14	6	17	5	6	3	129
121	80	25	24	7	28	7	8	3	182
124	67	20	20	6	20	8	9	2	152
131	72	24	24	8	17	10	11	4	170
	308	96	92	32	94	34	38	14	708 observed
	297	99	99	33	101	34	34	11	708 calculated on basis of 2 groups of 4 each.

X^2=3.91 P=.7893

TABLE 13. *Distribution of plants in 3 F_3 families for the characters glume colour and awn barbedness; cross Bearer × Lion, 1927.*

Family number	Black glumed		White glumed		Total
	Int. Rough	Smooth	Int. Rough	Smooth	
C-24-123	72	24	25	10	131
133	119	42	39	14	214
136	79	26	26	12	143
	269	92	90	36	468 observed
	271.5	90.5	94.5	31.5	468 calculated on basis of 2 classes each.

X^2=less than 1 P=very good fit

Linkage Relations.

It has been shown that glume colour and barbing of awns are independent of each other in inheritance, also glume colour and the length of rachilla hairs. A different relation apparently exists between the factor pairs long and short-haired rachilla and rough and smooth awn.

Long and short-haired rachilla and rough versus smooth awn: A cursory examination of table 14 shows that for independent assortment of the factor pairs involved, there are too many rough and intermediate rough-awned plants in the short-haired rachilla class, and not enough smooth and intermediate smooth-awned plants. The reverse is true in the long-haired rachilla class if the rough and intermediate rough-awned plants are combined. The fact that the intermediate rough-awned plants exceed the theoretical

number by 3.3 may be due to wrong classification. When Harris' goodness of fit method is applied, an X^2 of 104.8 and a very low *P* value are obtained. In general it may be said that an X^2 greater than 12 indicates a very poor fit. It is, therefore, probable that the factor pairs involved are linked in inheritance.

TABLE 14. *Distribution of F_2 plants for length of rachilla hairs and barbing of awns, cross Chinese × Lion, 1927.*

LONG-HAIRED RACHILLA				SHORT-HAIRED RACHILLA				
Rough	Int. Rough	Int. Smooth	Smooth	Rough	Int. Rough	Int. Smooth	Smooth	
821	305	360	123	376	109	31	13	2138 observed
905.1	301.7	301.7	100.6	297.6	99.2	99.2	33.1	2138 calculated on basis of 2 groups of 4 classes each.
Total=1609				Total=529				
X^2=104.8				P=very low				

As has been stated, the rough condition of the awn is due to two complementary factors. Since the rough, short-haired rachilla plants were obtained considerably in excess of the theoretical number on the basis of independent assortment, it may be assumed that one of these factors, either *R* or *S*, is linked with the factor *l* for short-haired rachilla. Distribution of F_3 plants in the Bearer × Lion cross, table 15, shows that the factors long *versus* short-haired rachilla and intermediate-smooth *versus* smooth awn are independently inherited. It may, therefore, be concluded that linkage exists between the factors *R* and *l* and not *S* and *l*.

TABLE 15. *Distribution of plants in 7 F_3 families for the characters long versus short-haired rachilla and intermediate-smooth versus smooth awn; cross Bearer × Lion, 1927.*

	LONG-HAIRED RACHILLA		SHORT-HAIRED RACHILLA		
Family number	Int.-smooth	Smooth	Int.-smooth	Smooth	
C-24-44	146	41	53	20	
59	55	18	8	4	
80	98	37	37	13	
83	72	24	23	8	
85	63	22	19	7	
104	49	16	15	6	
107	60	24	25	6	
	543	182	180	64.969	observed
	544.5	181.5	181.5	60.5968	calculated
	X^2=.212		P=very high.		

Since *L* is the factor for long-haired rachilla and *l* its allelomorph, the genetic constitution of Chinese would be *RRSSll* and of Lion *rr ss LL*. Each of the parents carry one of the dominant factors concerned in this linkage. The factors *R* and *l* enter the cross together, also *r* and *L*, and linkage exhibited is therefore in the form of repulsion. F_2 plants classified as rough contain the factors *R* and *S* while intermediate-rough plants contain the factor *R* only. Since the factor *R* is common to both classes, they should show the same linkage intensity and may therefore be combined in calculating the value of *r*. (table 14). Similarly in calculating the value of *s*, the intermediate-smooth and smooth-awned classes have been combined as they are not concerned in the linkage, thus:

LONG HAIRED RACHILLA				SHORT HAIRED RACHILLA			
Rough	Int. Rough	Int. Smooth	Smooth	Rough	Int. Rough	Int. Smooth	Smooth
821	305	360	123	376	109	31	13
1126		483		485		44	

$$M = 968$$
$$E = 1170$$
$$r = \tfrac{1}{2}\sqrt{1170 - 968} = 7.1$$
$$s = \tfrac{1}{2}\sqrt{1170 + 968} - r = 16.02$$
$$\therefore s:r :: 16.02:7.1$$
$$r = 1 \qquad s = 2.25$$

In plants heterozygous for two linked traits the gametes are not formed in equal numbers. The gametes with the parental combinations of factors are always more numerous than the gametes with the new combinations of factors. In this case the parental gametes are 2.25 times as numerous as the new combinations. On this hypothesis the per cent of cross-over gametes would be $\frac{1}{3.25} \times 100 = 30.8$ per cent, and the gametic ratio would be 1:2.25:2.25:1 instead of 1:1:1:1 which is the case for two factors independently inherited.

TABLE 16. *Theoretical number and sort of gametes produced in F_1 and the theoretical number and sort of zygotic combinations resulting in F_2 with two of the three factors so linked as to give 30.8 per cent crossing over.*

		RSL 1	RSl 2.25	RsL 1	Rsl 2.25	rSL 2.25	rSl 1	rsL 2.25	rsl 1
		RRSSLL	RRSSLl	etc.					
RSL	1	1	2.25	1	2.25	2.25	1	2.25	1
RSl	2.25	2.25	5.1	2.25	5.1	5.1	2.25	5.1	2.25
RsL	1	1	2.25	1	2.25	2.25	1	2.25	1
Rsl	2.25	2.25	5.1	2.25	5.1	5.1	2.25	5.1	2.25
rSL	2.25	2.25	5.1	2.25	5.1	5.1	2.25	5.1	2.25
rSl	1	1	2.25	1	2.25	2.25	1	2.25	1
rsL	2.25	2.25	5.1	2.25	5.1	5.1	2.25	5.1	2.25
rsl	1	1	2.25	1	2.25	2.25	1	2.25	1

Summating the values of all the genotypes within each of the 8 phenotypic classes, the following zygotic ratio is obtained:—

LONG-HAIRED RACHILLA				SHORT-HAIRED RACHILLA			
Rough	Int.-rough	Int.-smooth	smooth	Rough	Int.-rough	Int.-smooth	smooth
66.6	22.2	28.55	9.6	28.55	9.6	3.0	1.0
Total=126.95				Total=42.15			

The theoretical number of plants in the different phenotypic classes may then be calculated as follows: $\frac{66.6}{126.95} \times 1609 = 844.1$ rough plants with long-haired rachilla and similarly for other classes.

*TABLE 17. *Distribution of F_2 plants for rachilla length and awn condition with the theoretical ratio of plants calculated on a basis of 30.8 per cent crossing over;* Res. *19*: 31-472. 1920.

LONG-HAIRED RACHILLA				SHORT-HAIRED RACHILLA					
Rough	Int. Rough	Int. Smooth	Smooth	Rough	Int. Rough	Int. Smooth	Smooth		
821	305	360	123	376	109	31	13	2138	observed
844.1	281.4	361.8	121.6	358.3	120.5	37.6	12.5	2138	calculated on basis of 2 groups of 1609 and 529 each.

$X^2 = 5.74$ P = .6870

*Emerson's formula was used for calculating linkage intensities.

An examination of table 16 shows that the degree of correspondence between the theory and the facts is very high. P = .6870 which means that roughly in two-thirds of the trials, a worse fit may be expected, due to chance alone.

Discussion of Results.

From the evidence presented, it would seem that *Rr* and *Ll* lie in the same linkage group. Hor (*7*) showed that a fairly strong linkage intensity existed between these genes, the cross-over value from 13 F_3 populations showing repulsion, was 28.7 per cent. The writer obtained a cross-over value of 30.8 per cent based on the assumption that the parental combinations were 2.25 times as numerous as the new combinations. If 2.3 is used instead of 2.25 the agreement between theory and facts is slightly better and the cross-over percentage would be slightly lower. Using a higher figure such as 2.4, the X^2 is slightly increased and a worse fit obtained. This would tend to prove that the cross-over percentage is very close to 30. The results obtained, however, are in very close agreement with those obtained by Hor (*7*) and the slight difference may easily be attributed to environmental influences. It may be stated also that the writer worked with a population approximately six times as large as did Hor. Hor (*7*) obtained a weak linkage between the factors for glume colour and awn condition, the cross-over value being 41.48 per cent. The writer, on the other hand, has advanced fairly definite proof that these factor pairs are independently assorted, which also agrees with results obtained by Hayes *et al* (*5*) and Griffee (*1*).

Summary.

1. Crosses between Bearer and Lion and Chinese and Lion were used to determine the mode of inheritance of the differential characters rough and smooth awn, black and white glume colour, and long-haired and short-haired rachilla.

2. The factor pairs black *versus* white glume and long *versus* short-haired rachilla were shown to be inherited in a simple Mendelian manner, and to be independent of each other. It was also shown that the factor pairs black *versus* white glume and rough *versus* smooth awn are assorted independently.

3. The rough-awned condition is due to two complementary factors, the factor *R* producing a greater effect than the factor *S*. The factor *R* in the absence of *S* produces the intermediate-rough awn. Both are necessary to produce fully rough awn, and smooth awn is the result when both are absent. A 9:3:3:1 ratio was obtained in F_2, but Griffee (*1*) obtained a 12:3:1 ratio. Therefore, a phenotype (intermediate-rough awn) not previously reported, and which consists of 2 genotypes, has been added.

4. The selection of F_2 plants was not at random, a much larger number of smooth-awned plants being selected, the object being to select a white smooth-awned strain equal in agronomic value to the best rough-awned varieties used locally; nevertheless, homozygous F_3 lines were obtained for each of the 4 phenotypic classes. Some of the plants in both intermediate

classes segregated according to a single factor difference, while all smooth-awned F_2 plants bred true as would be expected. About one-half of the F_2 plants classified as rough, segregated into the 4 awn classes and would therefore have the genotypic constitution of F_1 plants, *RrSs*. Four plants were homozygous for roughness of awn, while 7 plants segregated on a single factor basis for rough and intermediate-rough awn. On the basis of random selection, 2/9 of the rough F_2 plants should have segregated in a 3:1 ratio for rough and intermediate-smooth awn. This segregation was not obtained, possibly due to the small number of plants selected.

5. A linkage was obtained between long and short-haired rachilla and the main factor for roughness of awn, the cross-over value being 30.8 per cent. The gametic ratio was taken as 1:2.25:2.25:1 in a repulsion series. When examined for goodness of fit, a slightly lower X^2 was obtained by assuming 1:2.3:2.3:1 to be the correct gametic ratio. This would slightly raise the linkage intensity and give a cross-over value of approximately 30 per cent.

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WEED DISTRIBUTION AND CROP CHARACTER IN RELATION TO SOIL TYPE IN SASKATCHEWAN*

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Weed distribution in relation to soil types in Saskatchewan is the primary matter to be considered in this paper. The other matter mentioned in the title, that of crop character, is of secondary importance, included chiefly for the purpose of linking weed distribution with regional or district agriculture.

The writer knows of no extensive weed studies according to soil types made in Western Canada. Groh (*1*) in connection with his weed survey of Canada, and Jackson (*2*) in the "Weeds of Manitoba" have outlined the distribution of a few of the more important weeds according to general soil character. Other weed publications of provinces and neighboring states which have been examined, refer to soils only in a very general way.

Data and deductions made in this paper are based on field studies made in connection with the Saskatchewan Soil Survey. Such studies include personal interviews with farmers as well as direct observations.

The writer appreciates the fact that weed distribution is influenced greatly by many factors, natural and artificial, as, for example, methods of farming, recency of introduction, mode of dispersal, etc. Nevertheless, as the result of many observations, I am convinced that adaptations to particular soil and climatic conditions largely determine the distribution of many weeds. The data collected and presented in this paper cover a sufficiently extensive area to show broad relations of weed distribution and, in many cases at least, are sufficiently detailed to illustrate weed distribution in relation to specific soil types. It is admitted that the observations are insufficient in thoroughness and detail to be considered as anything like exhaustive studies. However, the paper is presented merely as an initial step in what is hoped will be a worth while project.

In the soil survey we have divided Saskatchewan into six major soil belts‡. Major environment belts is likely a more suitable name for these as they reflect differences in natural vegetation and climate as markedly as differences in soils. These broad belts are further divided into many smaller, local belts on the basis of marked soil differences resulting from variations in geological origin. These smaller units are the soil series and types which, to date, we have named from some locality, usually where the type was first found. These preliminary explanations are given because the whole point of the paper is to show the relation of weed distribution to soil types and major environment belts, and, no doubt, many are not familiar with our viewpoint of such soil classification.

Before proceeding with the main body of the paper I should like to mention that Professor W. P. Fraser of the Department of Biology, University of

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‡A sketch map illustrating the zonal division of the Prairie Provinces is given in *Scientific Agriculture*, Vol. VIII, No. 10, pp. 651-664, June, 1928.

Saskatchewan, has given me valuable assistance especially in the identification of weeds and native plants which I have collected and submitted.

The general plan for presentation of data is to give it by survey districts, beginning with the Leader-Maple Creek area in our semi-arid southwest and ending with the Melfort area in our sub-humid black park and gray timber soil belts. I shall list the dominant weeds both as to general prevalence in the area and prevalence on soil types and groups of soil types. Common, rather than scientific, names are used for most plants in the main body of the paper. A list of the scientific names, however, is included at the end of the paper.

The Plains Light Brown Soil Belt

The dominant weeds in the Leader-Maple Creek area seem to be Russian thistle and tumbling mustard. Other weeds of importance occur, but none seems to rank with the above two in number or general importance except on certain soil types. On the Sceptre and Abbey clays and, to a lesser extent, on the Fox Valley silty clay loams, characteristic weeds are frenchweed and wild sunflowers. In addition Russian thistle and tumbling mustard occur, taking first or second place according to the moistness of the season, but are seldom as prevalent or troublesome as on the lighter soil types. Wild mustard, hare's ear mustard, and poverty weed are also characteristic weeds of the clays, but are usually of secondary importance. Poverty weed is mentioned as a secondary weed because of its present limited occurrence. However, because of its great seriousness on practically identical soil types in other districts and its increasing invasion on the Sceptre and Abbey types, it may, in the near future, become a most serious weed pest. In addition to the weeds mentioned many others occur, but not to the extent of deserving much consideration.

On the medium types such as the Fox Valley silt loam and Haverhill loam, Russian thistle and tumbling mustard seem to share honors only with each other. In dry years or periods of years, the Russian thistle seems to be dominant and in moist years, the tumbling mustard. Other weeds occur, but hardly to the extent of being seriously considered. Mountain sage assumes dominance on many abandoned fields, but seems not at all serious in crops.

On light soils, such as those of the Hatton and Caron series, Russian thistle shares honors with no other weed except possibly during very moist years. Tumbling mustard is a decided second and mountain sage here too has quite free play on abandoned lands.

Wild barley and gum weed, in this area, are characteristic of low, fairly poorly drained lands, especially on the alkaline clays. Barley grass lowers the quality of natural hay and native pasture in low lands, and is a nuisance because of its barbed seed. It gives little trouble in upland cultivated fields.

It is well to note that, as a belt, this part of the province is characterized by greasewood, salt grasses and purple samphire on alkali low lands, by a fairly considerable amount of sage brush on uplands, by more or less cactus in the drier places and by dryness of sloughs during much of the growing season of most years.

It is hardly an exaggeration to state that the lands which grow appreciable numbers of French weed, wild mustard and wild sunflowers and even small

amounts of poverty weed are undoubtedly the best wheat lands in the area, and that most lands on which these weeds are not present, and on which Russian thistle and tumbling mustard dominate, are generally uncertain or unsafe for wheat, but, if handled properly, produce profitable rye crops. A reverse relation holds for grazing, as the clays have a characteristic thin cover of June grass while the medium and fairly light soils, the Russian thistle lands, grow a more luxuriant stand of a mixture of June grass, spear grass and buffalo grass. Wheat is characterized, in most years over the whole area, by short straw and flinty kernels frequently shriveled by drought. I have no doubt either that the protein is usually higher than in black land districts of the province.

The Plains Brown Soil Belt

Weed distribution in this zone apparently does not differ greatly from that of the Light Brown Soil Belt, the differences becoming most marked as one approaches the Dark Brown or Prairie Plains Belt.

In general Russian thistle and tumbling mustard become of lesser importance, but still dominate on droughty soils, especially in dry years or periods of years.

On the heavy lands there is a noticeable increase in wild mustard, Frenchweed and poverty weed, the latter becoming a serious menace to wheat production in a number of districts, especially in areas of Abbey and Sceptre clays occurring to the west of Elrose. The habitat of poverty weed is discussed in some detail later in the paper. Wild oats, sow thistle and Canada thistle and other moist belt weeds occur in moist places, but are seldom serious.

On the medium lands of most well drained types, Russian thistle and tumbling mustard seem to dominate in dry years. In addition, Canada thistle, horseweed, lamb's quarters and wild oats become appreciable in moist places and biennial wormwood and Russian pigweed occasionally appear in like habitat.

On sandy lands Russian thistle is still usually decidedly dominant, and most weeds common to medium lands appear in fair abundance.

The natural vegetation changes but little. Differences which I have noticed are less sage brush and little cactus or greasewood, with some parkland grasses, especially *Avena Hookeri* and *Festuca viridula,* growing appreciably in places. In the sloughs rushes and sedges, persicaria and willows take the place of barley grass, and water stands the year around in many of them.

Prairie-Plains Dark Brown Soil Belt

Observations for the dark brown soil belt were made chiefly in the Rosetown and Weyburn soil survey areas.

Practically all weeds which occurred in the other belts occur in this one and a number of others become important. Lamb's quarters and wild oats are probably most prevalent, considering all soil types. Sow thistle and Canada thistle become sources of much concern, but are rather restricted as to habitat. Many other weeds become important on various soil types.

On heavy lands such as the Regina clay and silty clay loam, French weed, wild oats, wild mustard and lamb's quarters are generally dominant, and many

other weeds occur. Russian thistle and tumbling mustard become of minor importance and poverty weed apparently ceases to give trouble although it appears here and there in places especially adapted to the weed. More moist conditions seem to inhibit its growth on clays almost identical in character with the Sceptre clays on which it grows so well.

On medium lands, such as the Weyburn loams and clay loams, lamb's quarters, Canada thistle, wild oats, various mustards, Russian pigweeds, field bindweed and horseweed all occur in abundance, over the types, differing in dominance in various localities. In low, somewhat alkaline, areas sow thistle, Canada thistle and red root pigweed and barley grass, frequently become abundant. On light lands such as sandy soils of the Weyburn or Caron series there seems to be a greater abundance of most of the regional weeds than on any other types. Abandoned fields, in these sandy lands, which are not uncommon, are, in many places, breeding grounds for rank stands of a great variety of weeds. In fact I do not hesitate to express the belief that these abandoned areas of light soils in the Dark Brown Soil Belt contain, on the average, a greater variety of weed species than any other soil areas in the province. They are veritable happy hunting grounds for serious weed students. In addition to weeds common to the belt, these collections frequently have fairly abundant stands of Russian thistle, tumbling mustard, mountain sage and other weeds of dry land soil types, the former two frequently being dominant.

Natural vegetation has also changed markedly in this belt. Oat grass (*Avena Hookeri*), *Festuca viridula* and *Agropyron Richardsonii* have, to a large extent, replaced June grass and buffalo grass from the medium and heavy uplands and *Poa* spp., *Agropyron tenerum*, *Bromus inermis*, *Bromus ciliatus* and *Calamagrostis inexpansa* appear in low moist spots. Bluffs become fairly frequent, many sloughs hold water most of the time and one seldom sees sage brush, cacti, greasewood or other characteristic dry area plants. In this general belt, differences in weed distribution by soil types seem less striking than in the drier belts previously discussed. Crop character and other elements of agriculture seem to be transitional between the dry and moist belts.

The Black Soil, Park Belt

Observations for this belt were made chiefly in the Melfort soil survey area, and the soil types which are predominant are the Melfort silty clay loam and Waitville loam.

In this belt the differences in weed distribution by soil types are far less striking than in the other areas, so much so that I hardly feel warranted in making many sharp distinctions without further study.

However, the heaviest lands such as Melfort silty clay loam still maintain their monopoly of French weed and wild mustard, although these weeds become fairly abundant on other types. In addition brome grass as an escape gives some trouble and dandelion frequently becomes abundant. Quack grass is very serious on some medium and heavy soils and threatens serious invasion of other areas. Other weeds which occur are usually of equal or greater abundance on medium and light lands. These are wild oats, lamb's quarters, Russian pigweed, biennial wormwood, field bindweed, horseweed, wild sunflowers, various mustards, rose and yarrow. Sow thistle and Canada

thistle have appeared in places, but I have not yet been in any heavy or even medium area of fairly well drained land which has had serious trouble.

Canada thistle seems to be worse in sandy lands than on heavy, and sow thistle on somewhat poorly drained alkaline sandy lands.

Natural vegetation and agricultural adaptations have changed markedly in this belt, as compared to the drier plains and prairie belts. The dominant upland grasses seem to be mostly tall types such as *Agropyron Richardsonii* and *A. tenerum*, *Poa* spp., *Bromus inermis*, *B. ciliatus* and *B. pumpeliana*, and *Calamagrostis inexpansa*. White and black poplars are the dominant trees, and willows, rose, snowberry, dogweed, cherry, cranberries and Saskatoon berries are prevalent shrubs.

Noticeable agricultural characteristics you are already aware of:—the usually ranker growth of all crops, frequent lodging of grains, frequency of piebald wheat, and generally lower protein content, adaptability of grasses and oats, frequency of serious rust damage, marked differences in soil fertility, etc., as compared to the drier prairie and plains country.

The Timber Gray Soil Belt

Still another major belt remains to be considered, the podsol-like timber soils of the north, soils which more nearly approach those of humid eastern Canada than any others which we have; soils usually very low in nitrogen and organic matter and acid in reaction. However, as little of the typical timber lands have been cultivated we can as yet say little about weed distribution.

Before drawing conclusions from the material thus far presented I should like to discuss briefly some observations of the habitat of Poverty weed, a very serious pest in parts of Saskatchewan.

Poverty Weed

Rather detailed observations have been made as to the distribution of this weed. Part of this was in coöperation with Mr. W. J. Mather of the Department of Agriculture, Regina, located at Eston and working on the poverty weed problem in that district. This weed has become a serious menace to wheat production in parts of Saskatchewan. Mr. Mather is in possession of a large number of answers by farmers in response to a questionnaire requesting information as to the occurrence of poverty weed on their farms. In comparing the distribution map with our soil survey maps and data, it is very evident that this weed is practically confined to one soil type which in our soil survey we shall call the Sceptre clay. This soil, by the way, is not only undoubtedly the best wheat soil in the drier parts of Saskatchewan but includes most of the safe wheat lands in these same districts. Most other lands are unprofitable for wheat production or are profitable only with very careful handling. Consequently it is a matter of much importance to find effective means of combatting this weed. Furthermore, judging from my observations in a number of places last summer the weed is largely confined to places in fields which have moderately moist, slightly alkaline subsoils. It seems not to grow well either in very wet or very dry places in the fields. This habitat relation is frequently made evident in infested fields by the

occurrence of a complete or nearly complete ring of weed growth around the outer border of poorly drained spots. The weed occurs but little in the poorly drained place or on the drier upland. Where it does occur on drier uplands my own observation is that the location was such as to be possible to provide moist, slightly alkaline soils, that is, in or near shallow drainage ways, on uplands surrounded by higher lands, etc. We dug pits to study the subsoil and found the roots doing very well about six feet deep. Farmers report the roots at depths lower than ten feet in holes for wells.

In a study of the weed in native sod, I noticed it near the edges of poorly drained low spots—not sloughs with standing water—and associated with *Agropyron Smithii,* milk vetch, gum weed and other unidentified plants. The typical upland vegetation on the soil type is June grass with a sprinkling of white sage, and sage brush.

It so happened that in one such location which I studied, the low spot extended into a cultivated field on the opposite side of the road. The poverty weed in this field was the worst I have ever seen, a solid mat of the low, rather harmless looking weed practically killing out the wheat well back from the low spot. On about the level where June grass almost completely replaced *Agropyron Smithii* as the dominant grass in the sod on the opposite side of the road the wheat was practically free of the weed.

Conclusions

I should not like to finish this paper without drawing some conclusions, principally as a summary. Many of them are no doubt obvious and merely corroborate previous observations, possibly from a somewhat new viewpoint. For others some claim might be made to originality.

1. The major environment belts which we have mapped for Saskatchewan, which divide the province into zones on the basis of soil character, climatic conditions, natural vegetation and many considerations of agriculture, also fairly well mark out belts of general weed distribution and, within these general belts, many soil types and groups of soil types, mapped by the Saskatchewan soil survey, show marked differences in adaptations of many weeds.

2. The dominant factor determining the above general and soil type adaptations of weeds within Saskatchewan, seems to be moisture efficiency. This deduction is made on the basis of the evident correlation of weed habitat with soil texture, topographic position and climatic conditions. All of these factors indicate differences in the amount of available soil moisture as much or more than any other factor influencing plant growth. Furthermore, the influence on natural and cultivated vegetation, of irrigation, of cultivation and of seasonal differences in precipitation, all seem to emphasize the importance of the moisture factors under our conditions. Alkali, soil structure, differences in fertility, etc., also no doubt are important in determining weed habitats, but are secondary to moisture efficiency in most cases in Saskatchewan.

The dominance or general occurrence of weeds, both for major belts and on soil types, apparently then may be explained on the basis of differences in moisture efficiency. Important weeds of the more moist, park or black belt are wild oats, quack grass, French weed, wild mustard, wild sunflowers, perennial sow thistle, Canada thistle, lamb's quarters, dandelion, wild buckwheat,

biennial wormwood, Russian pigweeds and red root pigweed. In this connection it is significant to note that the weed bulletin of the Ontario Department of Agriculture (*3*) lists wild oats, quack grass, wild mustard, perennial sow thistle, French weed, lamb's quarters and wild buckwheat as prevalent and some of them very bad. Ontario conditions, of course, are distinctly more moist than for settled Saskatchewan.

Important weeds for the southwest dry area in Saskatchewan are Russian thistle, tumbling mustard, hare's ear mustard, poverty weed, wild sunflowers, wild mustard, French weed, wild barley, mountain sage and probably some mustards not considered in the paper.

It is significant in this connection to note that the weed bulletin from the Montana State College (*4*) mentions tumbling mustard, Russian thistle, and barley grass and poverty weed as prevalent in dry areas.

In the above lists weeds of the moist belt that are also common to the dry belt are found in the latter belt almost wholly on the most drought resistant soils.

In considering the above weeds, I feel quite warranted in holding the opinion that few of the weeds listed as typical of the moist belt will become serious in the drier areas except under conditions permitting a moisture efficiency approaching that of the moist belt. Thus, in my observation, French weed, wild mustard, wild sunflowers, Canada thistle and lamb's quarters become noticeably prevalent only on the most drought resistant uplands of the dry area such as the Sceptre and Abbey clays, on lands with high water tables, on low moist lands or on irrigated lands. Sow thistle, quack grass and wild oats are even more restricted, so that I have little fear of these weeds becoming serious except in local especially favored places.

The Montana bulletin states that Canada thistle, dandelion and sow thistle grow well only under irrigation and that quack grass requires much moisture for development.

I also feel warranted in holding the opinion that Russian thistle and tumbling mustard will not be serious weed pests in the moist environment belts except where local conditions result in subnormal moisture efficiency as, for example, on very sandy lands or on excessively drained knolls with light subsoils. Poverty weed, I believe, has little chance in moist belts even in restricted localities.

The Manitoba weed bulletin (*2*) is quite emphatic in its statements as to the restriction of Russian thistle and tumbling mustard to light drifting soils.

In other words, weeds not typical for moisture conditions prevailing in a given major belt occur there mostly as outposts on particular soil types, whose moisture efficiencies approach those of another belt.

3. The greatest variety of weeds, as well as of natural vegetation, seems to occur in the dark brown prairie belt, transitional between the more moist and the drier parts of the province. Besides supporting most of the common weeds of neighboring belts it also has some which are more characteristic of its own environment than of other belts.

4. Poverty weed in Saskatchewan seems to be best adapted to moderately moist, slightly alkaline places on the Sceptre clay in places on this soil type where *Agropyron Smithii* grows well.

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Scientific Names of Plants

Biennial Wormwood	*Artimesia biennis*
Black Poplar	*Populus balsamifera*
Blue burr	*Lappula echinata*
Brome grass	*Bromus inermis*
Cactus	*Coryphantha*, spp.
Canadian thistle	*Cirsium arvense*
Dandelion	*Taraxicum efficinale*
French weed	*Thlaspi arvense*
Grease wood	*Sarcobatus vermiculatus*
Gum weed	*Grindeli squarrosa*
Grama grass	*Bouteloua gracilis*
Horseweed	*Leptilon canadensis*
Hare's ear mustard	*Conringia orientalis*
Indian mustard	*Brassica juncea*
June grass	*Kohleria gracilis*
Lamb's quarters	*Chenopodium album*
Milk vetch	*Astragulus gonatus*
Oat grass	*Avena Hookerii*
Poverty weed	*Iva axilaris*
Perennial Sow thistle	*Sonchus arvensis*
Quack grass	*Agropyron repens*
Russian thistle	*Salsola Kali*, L.
Russian pigweed	*Axyris amaranthoides*
Rose	*Rosa* spp.
Red root pigweed	*Amaranthus retroflexus*
Rushes	*Juncacea*
Sedges	*Cyperaceae*
Sage brush	*Artimesia tridentata* or *cana*
Salt grass	*Distichlis spicata* and *Distichlis stricta.*
Silver weed	*Argentia anserina*
Spear grass	*Stipa comata*
Tumble mustard	*Sysimbrium altissimum*
Wild mustard	*Brassica arvensis*
Wild sunflower	*Helianthus* spp.
Wild barley	*Hordeum jubatum*
Wild oats	*Avena fatua*
Wild buckwheat	*Polygonum convolvolus*
White sage	*Urotia lanata*
Western wheat grass	*Agropyron Smithii*
Willows	*Salix* spp.
White poplar	*Populus tremuloides*
Yarrow	*Achillea millefolium.*

THE AGRICULTURAL VALUE OF HARD SEEDS OF SWEET CLOVER IN ALBERTA*†

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In Section III of a previous paper the results of the work on this subject covering the growing season of 1927 were discussed, using the method referred to, for want of a better term, as the equation method. During the winter 1927-28, the test plots were left intact and in the spring of 1928 all plots were checked twice for additional germination and to ascertain loss of plants due to winter killing. In this paper it is proposed to discuss these additional data. Four plots in all were seeded in 1927, three at the Dominion Experiment Station, Lacombe, on May 3rd, May 11th, and June 1st respectively, and one at Brooks on June 3rd. The date of seeding at Brooks and the last date of seeding at Lacombe are normal for their respective districts.

Table 1 gives details of the laboratory tests on the samples used in this investigation.

TABLE 1. *Details of samples used in 1927 investigation (sweet clover).*

Sample No.	Lab. test count after 5 days Germ.	H.S.	Weak	Broken
1	37	57	6	1
2	21	77	2	—
3	58	32	6	—
4	85	7	5	4
5	66	28	2	1
6	70	24	3	2
7	86	5	5	3
8	81	15	2	2

*In a sense this may be considered as a continuation of the paper "The Agricultural Value of Hard Seeds of Alfalfa and Sweet Clover under Alberta Conditions", previously published (Sci. Agr. *8*: 4. 1927), and where in this work reference is made to results previously reported, that paper is indicated.

WINTER MORTALITY

In the fall of 1927 the plots were checked and all plants which went into winter alive were noted. In the spring 1928 check it was observed that many of these had been killed, but a few old plants were observed which had not been in evidence in the previous fall though they had germinated during the summer of that year. In table 2 these have been added to the fall check and are shown as having been alive at that time.

TABLE 2. *Standing of plots in the fall 1927 and in spring 1928. (per cent.).*

Sample No.	Lacombe No. 1 Fall	Lacombe No. 1 Spring	Lacombe No. 2 Fall	Lacombe No. 2 Spring	Lacombe No. 3 Fall	Lacombe No. 3 Spring	Brooks Fall	Brooks Spring
1	7	6	15	14	16	15	37	34
2	10	9	15	14	18	17	17	16
3	10	9	21	20	20	20	54	50
4	13	12	33	32	15	15	59	54
5	12	11	13	11	12	11	47	38
6	23	19	22	22	15	15	58	50
7	4	4	28	26	11	9	52	43
8	12	12	17	16	30	29	43	40

†Contribution from the Laboratory Division, Seed Branch, Dept. of Agriculture, Ottawa.
‡Supervising Analyst.

These data were analysed by the equation method with results tabulated in table 3.

TABLE 3. *Contributory field germination of hard and permeable seeds compared at fall and spring.*

	Time	Field Germ. Hard Seeds	Field Germ. Perm. Seeds	Agr. Val. H.S. where P.S.=100
Lacombe No. 1	Fall	8.3	15.0	55.5
	Spring	7.0	13.8	50.9
Lacombe No. 2	Fall	8.2	28.6	28.7
	Spring	7.3	27.2	26.8
Lacombe No. 3	Fall	18.6	17.4	107.2
	Spring	17.3	17.1	101.2
Brooks	Fall	19.2	64.6	29.7
	Spring	18.8	56.4	33.3

(Note:—This table cannot be directly compared with Table 2 in the paper referred to in the foot-note, since the latter includes all germination up to the last count, whereas in this table only plants surviving at that date are included.)

The last column of this table shows the relative value of the hard seeds as compared with that of the permeable before and after the winter in each plot. It will be seen that in each of the Lacombe plots the hard seeds show somewhat lower values in the spring than in the fall, i.e. plants produced by hard seeds appear to have suffered relatively more through winter killing than those produced by permeable seeds. The reverse of this is the case in the Brooks plot. It is to be noted that at Lacombe the winter is somewhat more severe than at Brooks, which lies at a considerably lower elevation; thus it appears that plants produced by hard seeds are somewhat less winter hardy under less favourable winter conditions than the product of permeable seeds.

It is interesting to compare this result with that previously reported for alfalfa in which the reverse condition appears to obtain.

A study of the winter survival value of plants produced from seeds germinating at different counts substantiates this finding, and, apart from its own interest, is introduced here as additional confirmation of the value of the equation method. This is shown in table 4.

TABLE 4. *Winter survival value of plants produced from seeds germinating at different counts.*

Count No.	Plants present in check-up 1928	Plants present in fall 1927	Winter survival value %
Lacombe No. 1 Plot			
1	123	132	93.2
2	29	34	85.3
3	61	63	96.8
4	34	42	81.0
Lacombe No. 2 Plot			
1	326	336	97.0
2	65	67	97.0
3	53	55	96.4
4	24	32	75.0
Lacombe No. 3 Plot			
1	278	289	96.2
2	81	83	97.6
3	30	31	96.8
4	7	11	63.6
Brooks Plot			
1	607	680	89.3
2	323	367	88.0
3	13	15	86.7
4	32	38	84.2

In examining this table it is seen that the degree of winter hardiness tends to become less as the germination is later. This tendency is not, on the whole, very marked for the first three counts but is quite marked in the fourth. It has previously been shown that hard seeds are inclined to give later germination than permeable; hence we must conclude that the plants produced by them are somewhat less hardy than plants produced by permeable seeds. The sudden drop in winter survival value of the plants produced in the last count, however, seems to point to germination too late to enable the plants to become properly established, as the main cause of the lower degree of winter hardiness.

In the Brooks plot this sudden drop does not occur, probably due to the more favourable winter season at that place. Yet there is a slight regular fall in these values from the first count which seems to contradict the results for this plot reported in table 3. Some of these later counts, however, produced very few plants and the loss of one or two would make much more difference to the final results than if we had to deal with a larger number. Hence it is not necessary to stress this discrepancy, but to observe that, broadly speaking, the figures shown in table 4 substantiate those in table 3.

Additional Germination After the Winter

About the first week in May, 1928, the plots were checked over for additional germination, and again a few weeks later, after which no additional germination was evident. These results are reported in table 5.

Table 5. *Percent germination of seeds wintering over in soil.*

Sample No.	Lacombe No. 1	Lacombe No. 2	Lacombe No. 3	Brooks
1	8	10	11	
2	11	12	25	No
3	2	2	3	additional
4	0	1	2	germination
5	1	2	5	after
6	3	1	4	winter.
7	0	1	1	
8	0	1	2	

These results were analyzed by the equation method in order to ascertain the contribution of each factor: hard and permeable seeds. This analysis is shown in table 6.

Table 6. *Relative value of hard and permeable seeds contributing to additional germination after winter.*

	Field Germ. Hard Seeds	Field Germ. Perm. Seeds
Lacombe Plot No. 1	14.3	—1.9
Lacombe Plot No. 2	15.6	—1.6
Lacombe Plot No. 3	27.4	—2.7
Brooks	No additional germination after winter.	

The method of least squares used in solving the equations in what has been referred to as the "Equation method" gives the solution which best fits these equations. It is obvious that the negative values reported in table 6 as the field germination of the permeable seeds can have no practical meaning. The numbers are all close enough to zero compared with the figures for hard seeds, however, as to indicate without doubt that the hard seeds alone had any part in this additional germination. This is exactly what would be expected, since it would only be the hard seeds which would resist germ-

inative influences sufficiently to enter into the winter in such a condition as to be able to germinate the following spring, and it affords a further indication of the applicability of the equation method.

Total Germination Over Period Covered by the Experiment. (Growing Season 1927 to Late Spring 1928)

It has been pointed out from time to time that seedlings reported as germinated at one time in some cases subsequently disappeared. Such seedlings have not been included in any of the results so far reported in this paper, but it was felt that it would be of interest to consider the total germination of each sample throughout the experimental period. This is given in table 7, and in table 8 the analysis of these figures by the equation method is shown.

Table 7. *Total germination over period of the experiment.*

Sample No.	Lacombe No. 1	Lacombe No. 2	Lacombe No. 3	Brooks
1	16	47	31	55
2	29	38	47	21
3	31	35	31	63
4	37	45	24	62
5	37	29	24	57
6	49	38	25	62
7	23	40	20	57
8	29	29	37	55

Table 8. *Analysis of Table 7 by equation method.*

Plot	Field Germ. Hard Seeds	Field Germ. Perm Seeds	Agr. Val. H.S. where P.S.=100
Lacombe No. 1	27.5	37.9	72.6
Lacombe No. 2	41.5	39.5	105.0
Lacombe No. 3	44.8	25.5	175.5
Brooks	36.0	70.9	50.8
Average			101.0

From this we see that there is a great diversity of results regarding the relative contribution of the hard seeds in the four plots. It is interesting to note that this contribution increases progressively the later the date of seeding at Lacombe, reaching its maximum at the date which is normal for the district, while under a different set of conditions—at Brooks—the contribution is lowest of all, even though seeding was at the date normal for that district. It will be remembered that in this plot there was no additional germination, hence the figure reported is the same as that previously reported for the relative hard seed value at the end of the previous season. Table 9, shows these relative hard seed values for the four plots, as previously reported at the end of the 1927 season, and also as reported in table 8, for the total germination over the whole experimental period.

Table 9. *Relative agricultural value of hard seeds at the end of the first growing season and at the end of the experimental period compared.*

Plot	Agr. Val. of H.S. where P.S.=100 end 1927	end exp. period
Lacombe No. 1	32.9	72.6
Lacombe No. 2	61.2	105.0
Lacombe No. 3	77.5	175.5
Brooks	50.8	50.8
Average	55.6	101.0

While the relative value of the hard seeds increases in the same order for the three Lacombe plots, it is much greater at the end of the experimental period than at the end of the first growing season. This is clearly due to the additional germination after the winter which was entirely contributed by the hard seeds as shown above. At Brooks the first growing season was apparently so favourable that all the seeds which were going to germinate did so in that period.

The average value of the hard seed contribution compared with that of the permeable, considering all seeds which had germinated, is approximately 100 per cent. We must conclude therefore that during the first growing season, when factors responsible for mortality are not considered, hard seeds have an agricultural value of approximately 50 per cent of that of the permeable seeds, but that during the second season they make as great a contribution to the crop as the permeable seeds.

It should be stressed however, that climatic and probably other factors have a marked influence in this regard, as witness the different results obtained in the different plots, and that it would be unsafe to apply this conclusion to all conditions and seasons until considerably more data had been secured.

Total Plants Surviving at End of Experimental Period. (Late Spring 1928)

Whatever may have been the factors responsible for mortality, there was nevertheless considerable mortality, not only due to winter-killing but also due to other causes. Table 10 shows the total percent plants surviving and table 11 shows the analysis of these results by the equation method.

Table 10. *Per cent plants surviving in late spring 1928.*

Sample No.	Lacombe No. 1	Lacombe No. 2	Lacombe No. 3	Brooks
1	13	21	22	34
2	18	23	36	16
3	11	22	23	50
4	13	33	16	54
5	12	13	14	38
6	22	23	17	50
7	4	27	11	43
8	12	16	30	40

Table 11. *Analysis of Table 10 by equation method.*

Plot	Field Germ. Hard Seeds	Field Germ. Perm. Seeds	Agr. Val. H.S. where P.S =100
Lacombe No. 1	18.3	12.7	144.6
Lacombe No. 2	18.6	26.2	70.9
Lacombe No. 3	33.9	17.0	199.1
Brooks	18.8	56.4	33.3
Average			112.0

Comparing the average of the four plots above with the average shown in tables 8 and 9 (101.0), we may conclude that practically speaking, mortality has not affected hard seed seedlings differently from permeable seed seedlings. However individual plots have been differently affected, but in no regular way, and we can only conclude that this effect is purely accidental and not related to hard seededness. Hence the conclusions reached in the previous section may be considered as unchanged by these results.

Summary

(1) Four plots were seeded in 1927, the results of which have been discussed for the first growing season in a previous paper. This paper embodies additional results secured on the same plots after the winter.

(2) Plants produced by hard seeds appeared to be somewhat less winter-hardy under less favourable winter conditions than those produced by permeable seeds.

(3) This effect however, appeared to be due rather to the fact that seedlings produced by hard seeds germinated too late in the season to become properly established to withstand the winter than to any inherent weakness in the seedlings themselves.

(4) Additional germination after the winter was entirely contributed by the hard seeds.

(5) During the first growing season hard seeds had about 50 per cent of the agricultural value of the permeable, but when the whole experimental period was considered (growing season 1927 to late spring 1928) they had approximately the same value as the permeable seeds.

Acknowledgment

May I again express my thanks to the officials of the Dominion Experimental Station at Lacombe and the Dominion Irrigation Experiment Station at Brooks for their continued interest and help.

A METHOD OF REMOVING BORDERS FROM GRAIN PLOTS*

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The practice of removing borders from experimental plots is now considered an essential part of experimental work. Agronomists should be vitally interested in any method which will cheaply, easily and efficiently remove border rows from field plots.

Barber (*1*) found that rows bordering on pathways produced more straw and grain, and were later in maturing than interior rows. Stadler (*6*) and Kiesselbach (*4, 5*) found that competition between dissimilar crops for moisture, nutrients and possibly light, resulted in error in crop tests. Cole and Hallstead (*2*), working with Kafer and Milo, obtained a very marked increase in yield from the outside rows. Hulbert and Remsberg (*3*) corroborated the work of previous investigators and, in addition, found that when different varieties were compared some were influenced to a greater extent than others when the border rows were included in the calculations.

Although the importance of eliminating borders from plots before yields are taken has been recognized by experimental workers for some time, it is only within the last decade that this practice has been followed by experimental institutions in the prairie provinces.

The problem of removing borders from a thousand or more grain plots during harvest time has resulted in a considerable amount of extra work at a busy season of the year. For this reason, each experimental station has been forced to devise some simple method of removing borders, which would do the work in the least possible time. In 1925 and 1926 a hand sickle and scythe were used to cut the borders from several hundred cereal variety plots at Scott. This method was slow and cumbersome. To cut and bind the borders from 25 one-fortieth-acre plots by this method was about all that one man could do in a day. In the busiest part of the season it was necessary to rake up the borders after they had been cut, and leave them in piles untied at the ends of the plots. This afforded opportunities for mixing varieties and, in addition, gave the plots a decidedly untidy appearance.

A number of experimental workers in agriculture when visiting the Dominion Experimental Station, Scott, have shown keen interest in our method employed for removing the plot-borders. Favorable comment offered and enquiries received on this subject prompt us to present a brief paper on the subject.

In 1927 we decided to eliminate the borders from all grain plots. This entailed the removal of borders from between six hundred and seven hundred plots. Instead of attempting to construct a special machine, we sought some method of using the binder for cutting the borders. For cutting off the ends of the plots we attached an extension-guard to the fifth guard in from the outside of the binder table. By painting this guard white and driving

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slowly no difficulty was experienced in removing the end borders. W found that it was better to do this on a calm day. We next tried to c the two border rows on each side of the plot with the binder, but it w found impossible to drive the binder satisfactorily for this work unless t teamster was given a guide to follow. We then tried having a man wa between the two border rows and the interior rows of the plot and press t plants apart near the base with his hands. There was enough sap le in the plants at this stage of maturity to prevent them from breaking o and they did not spring back enough to close the opening. After this oper tion the teamster had no difficulty in removing the two border rows wi the binder.

Working on this idea, one of our student workers, Kenneth Campbe made a machine to do this work of separating the rows. This is a simp and inexpensive implement. It consists of a triangular piece of wood mac from "two by fours" attached to the frame of a Planet Junior plough with wheel in front. (See Figure 1.). The operator pushes the machine throug the plot between the second and third rows from the outside. This leav a distinct V-shaped space between the two border rows and the main pl (Figure 2.). With this separation effected a capable teamster experienc no difficulty in using a binder for harvesting the border rows and the ma plot separately.

When a motor is not used to operate the binder, a rope, within eas reach of the teamster, can be used to trip the knotter when the binder clea itself.

In describing the working of this method, its use on one-hundreth-ac plots will best serve to illustrate its efficiency. These plots are seven and half feet wide with a pathway of two feet between them. Plots of this si

FIGURE 1. The machine used for separating the border rows from the portion the plot to be harvested for yield.

FIGURE 2. The passage of the machine between the border rows and the main portion of the plot leaves a distinct V-shaped opening.

FIGURE 3. The two remaining border rows of one plot and the border rows of the adjacent plot are cut in one operation with the binder.

are not cut consecutively except when special conditions demand. For this reason, the binder operator usually misses several plots so as to facilitate operations, and avoid injury to standing grain. While the binder is in progress, border rows are opened up in advance by the special machine. When one border is removed as shown in Figure 3, the next operation is to cut completely, with one swath, the portion of the plot from which the yield is

FIGURE 4. After the border rows on one side of a plot are cut the main portion of the plot is cut in one swath, leaving the remaining border rows standing.

taken. (See Figure 4.). Another advantage of the "separating machine" is forcefully brought out at this time. With the plants from outside of the main plot leaning inwards, a six-foot binder completely gathers all material required for yield and avoids missing occasional heads which lean over when ordinary methods of cutting are used. The cutting of the portion of the plot for yield leaves the two border rows on the opposite side of the plot standing, as shown in Figure 4.

The next operation is to cut this border. With the width of pathway mentioned, the binder cuts the two border rows remaining and the border rows of the adjoining plot in one operation. This is illustrated in Figure 3.

When plots are parallel the binder continues in a straight line cutting borders from plots in different ranges without a stop.

From twenty to twenty-two borders and plots can be cut in an hour. Exactly the same number is cut when borders are not considered because plots of this size require two swaths of a binder. This means that plots can be left entire until harvest time and borders removed without loss of time in the busy season.

This simple, cheap and efficient method of removing borders undoubtedly has a wide application for experimental workers in agronomy.

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ACTIVITES DES SECTIONS FRANCAISES DE LA C.S.T.A.

Section de Quebec

Le 15 avril, la section de Québec, sous la présidence de M. Léo Brown, a eu une belle assistance à son diner-causerie au restaurant Kerhulu.

M. J.-H. Lavoie, I.F., Chef du Service de l'Horticulture et récemment élu président du Conseil Canadien d'Horticulture, était l'hôte d'honneur.

Le conférencier de la soirée fut M. Henry Lefèvre, Ingénieur Agronome de l'Institut agronomique de Paris et Directeur, pour le Canada, de la N.V. Potash Export My of Amsterdam Holland.

Au dessert, le Président remercia tout d'abord les membres de la Section de Québec de l'avoir élu au poste qu'il occupe, adressa des félicitations à l'hôte d'honneur et enfin présenta le conférencier en termes appropriés.

M. J.-H. Lavoie expliqua brièvement le but du Conseil Canadien d'Horticulture.

"Ce Conseil, dit-il, fondé il y a quelque dix ans, s'est donné pour but de prendre les intérêts généraux de l'horticulture au Canada et de grouper sous une même tête les petites sociétés, pour avoir plus de poids auprès des pouvoirs publics".

Sans autre préambule que les paroles d'usage, M. Lefèvre aborda directement son sujet : Les relations qui doivent exister entre les techniciens à l'emploi de l'industrie et ceux qui sont au service des pouvoirs publics.

"L'évolution du dernier quart de siècle s'est manifestée dans tous les domaines de l'activité humaine en industrie comme en agriculture. La science agricole a progressé et les techniciens, étant donné leur situation qui les met en relation étroite avec les cultivateurs, connaissant leurs besoins et, dans bien des cas, leur situation financière, sont en mesure de leur rendre d'appréciables services autant ceux à l'emploi de l'industrie qu'au service des pouvoirs publics". Au moyen de quelques exemples, il illustra les principes énoncés.

Le conférencier insista ensuite sur l'étroite coopération dans le travail des techniciens agronomes, dans quelque domaine d'activité qu'ils soient placés. "Nulle part, dit en terminant M. Lefèvre, je n'ai rencontré une coopération aussi complète de la part des autorités gouvernementales que celles que nous rencontrons au Canada."

M. Narcisse Savoie, après avoir remercié le conférencier, mit en relief certains passages de sa causerie.

Au Département de l'Agriculture, ajouta-t-il, l'Honorable M. Caron s'est donné depuis plus de vingt ans à la cause agricole pour laquelle il s'est dépensé sans compter et il laissera un souvenir vénéré et impérissable.

N.P.

SECTION DE STE.-ANNE DE LA POCATIERE

Jeudi, le 25 au soir avait lieu à l'Ecole d'Agriculture une réunion de la Société des Agronomes Canadiens sous la présidence de M. l'abbé François Xavier Jean, ptre, président de la section de Ste-Anne.

Monsieur l'Abbé Jean sut présenter le distingué conférencier de la veillée dans un de ces petits discours dont il a le secret, et dont la rhétorique et la justesse de ton se partagent les honneurs.

Mgr. Lebon, supérieur du Collège, commença sa conférence en parlant des origines très hunbles de celui qui devait être plus tard M. François Pilote.

Son père était serviteur chez son curé, et le jeune François n'avait que quatre soeurs. Son pasteur eut vite fait de découvrir les qualités brillantes de cet enfant, et il le mit au Séminaire de Québec. Le jeune Pilote fut très brillant dans ces classes; il oublia même de passer par la cinquième, ce qui ne l'empêcha pas de décrocher la troisième place en rhétorique. Il avait entre autres pour confrère M. J.T. Taschereau, le père de l'Honorable Premier Ministre de la Province.

Il entre en 1832 au Grand Séminaire après avoir passé une année à St-Sulpice, à Nicolet et à la Rivière Ouelle, on le demanda au Collège de Ste-Anne qui n'avait pas dix ans d'existence.

Il y remplit la charge de directeur, professeur de théologie, procureur et bientôt de supérieur. Il semble bien que l'abbé Pilote fut l'inspirateur de tout ce qui s'est passé d'extraordinaire au Collège de Ste-Anne de 1840 à 1870. Il fut le constructeur de presque tout le vieux collège sauf ce que M. Painchaud avait construit en 1829. Une ère nouvelle s'ouvrit en 1901 et se continue pendant 20 années.

M. Pilote fut un homme supérieur, également apte aux travaux de l'esprit et aux travaux manuels. On raconte qu'il allait lui même à la carrière encourager les hommes par son travail; il écrivit beaucoup, et on dit qu'à sa mort disparurent par la négligence de ses exécuteurs testamentaires deux pleines valises de lettres, dont les carnets nombreux indiquent le sujet et la date. On conserve beaucoup de notes de prônes, de sermons, de projets, etc.

Il fut un excellent supérieur de Collège, il fonda, malgré bien des gens (car son oeuvre était amèrement discutée encore trente ans après sa fondation), la cinquième Ecole d'agriculture de la Province, mais la seule qui sut résister jusqu'aujourd'hui.

Il organisa les Sociétés de Colonisation de l'Islet et de Kamouraska pour diriger les gens du sud vers les riches régions du lac St-Jean, et en 1861, il écrivit un livre "Le Saguenay". En 1851, il affirme quelque part être débordé de travail parce qu'il tient dans sa main les fils de ces organisations, à part ses travaux ordinaires.

En 1870, il quitte le Collège et prend la cure de St-Augustin, comté de Portneuf, qu'il garde jusqu'à sa mort. Il réforme tellement cette paroisse au point de vue agricole que trente ans après sa mort son influence se fait sentir encore, et l'un de ses élèves, M. Couture mérite la plus grande décoration de la Province, soit une médaille d'or du Mérite Agricole.

Il fonde le Couvent de St-Augustin, et jette mêmes les bases d'une Communauté de dames qu'on appelle dans l'intimité "Les Pilotines"......

Dans cette institution où on lisait dans la façade ces mots: "Education et Industrie" était une école ménagère avant la lettre, et l'on voit dans les documents du temps, que l'abbé Pilote avait des idées très nettes sur le genre d'éducation que devaient recevoir les jeunes filles de la campagne dans les couvents.

Il fut à son poste de pasteur tant que ses forces ne l'eurent pas complètement abandonnées. Il mourut en 1886, regretté de tous ses paroissiens et de tous ceux qui savent apprécier un homme de cette trempe.

En 1918 l'Ecole eut l'honneur de voir revenir près d'elle son fondateur, de qui elle conserve pieusement la mémoire et qu'elle se propose d'honorer dans la pierre et dans l'airain.

"Son nom est gravé dans la pierre et dans le bronze, et son souvenir reste dans le coeur des braves" disait le président de la section de Ste-Anne, M. l'abbé F.-X. Jean.

Les agronomes ont profités de cette dernière réunion d'avril pour faire l'élection des nouveaux officiers:

Les élus furent:

Président: J.-A. Godbout, professeur à I'Ecole d'Agriculture.

Vice-président: Paul Carignan, agronome officiel du comté de Montmagny.

Sec.-trésorier: Elzéar Campagna, professeur à l'Ecole d'Agriculture.

Représentant à l'Exécutif Central: La président, M. J.-A. Godbout.

Conseillers: M. C. Gagné, professeur à l'Ecole d'Agriculture, et M. L. Raynauld, Ass.-régisseur à la Station Expérimentale de Ste-Anne.

Délégués Officiels pour la convention annuelle, MM. G. Bouchard, M.P., professeur à l'Ecole d'Agriculture, et M. L. Raynauld de la Station Expérimentale.

E.C.

Section Quebec et Ontario Septentrionale

Le but principal que poursuit la Section Septentrionale Québec et Ontario de la Société des Agronomes Canadiens est de coordonner le travail de vulgarisation de la science agronomique. C'est ainsi que les régisseurs et chefs de départements des deux fermes expérimentales du Nord, les agronomes de district, les inspecteurs de semences, les médecins-vétérinaires, les gérants de coopératives agricoles et les agents des terres de la Couronne dressent un programme au commencement de l'année, lequel est étudié en assemblée générale et amendé de façon à en faire un programme uniforme d'action.

Dans ce but deux comités ont été formés, un comité d'étude et un comité de publicité. Le premier s'occupe de signaler aux membres les expériences nouvelles après s'être enquis des possibilités d'en appliquer les principes dans le Nord; le second recueille les divers écrits publiés dans les journaux, revues et bulletins agricoles; il analyse ces écrits, les amende de façon à en appliquer les principes dans le Nord et les publie sous une forme spécialement adaptée aux besoins des cultivateurs de notre région.

Le travail de ces deux comités est très ardu. Ce travail leur est facilité grâce à l'activité de notre président qui a l'avantage de visiter la plupart des membres plusieurs fois dans le cours de l'année.

L'isolement de nos membres est un grave inconvénient à une forte action de cette section. Ceci se comprend facilement si l'on sait qu'une distance de 210 milles sépare nos membres résidant sur le parcours du Transcontinental et qu'il existe une distance plus grande encore entre les membres du nord et du sud de notre section.

Les conditions identiques de milieu nous forcent à enseigner une doctrine uniforme, même dans les détails de son application. C'est pourquoi nous espérons que notre travail, qui s'effectue lentement, peut n'arriver qu'à de bons résultats dans toute l'étendue de notre territoire.

La culture de la graine de trèfle, du blé Garnet, de l'avoine Alaska et des pois Chancelier, l'élevage des volailles et du porc sont les branches qui attirent le plus l'attention de nos membres et qui doivent être développées le plus rapidement possible dans notre territoire; et ce n'est que par la coopération entre nos membres que nous y parviendrons. .

Nous avons dû tâtonner, plus longtemps ici qu'ailleurs peut-être, parce que nous n'avons pu bénéficier de l'expérience des prédécesseurs que nous n'avons eus et c'est pourquoi le travail de nos deux fermes expérimentales offre tant d'intérêt pour nous, mais il nous manque encore une ou deux écoles moyennes d'agriculture pour procurer à nos jeunes les moyens de s'instruire dans la science agricole et de leur procurer une occasion de cultiver le sol en applicant les méthodes modernes de culture. Ce sol doit être cultivé avec d'autant plus d'ardeur que notre territoire offre beaucoup d'attraits pour les mines et pour l'exploitation forestière. C'est encore un but poursuivi par notre section et un travail a été commencé en ce sens au début de la présente année.

A.J.R.

Section de Montreal

Au diner-causerie mensuel des techniciens agricoles de la région de Montréal, en l'absence de M. H.N. Nagant, président de l'association, M. J.-A. Leclerc de Laprairie, vice-président, occupait le fauteuil. M. J.-H. Lavoie, Chef du Service de l'Horticulture de la province et président du Conseil Canadien d'Horticulture, était le conférencier de la réunion.

M. Lavoie insista sur une meilleure classification de nos produits maraîchers pour empêcher les légumes étrangers d'envahir notre marché, et sur une culture ornementale plus soignée autout de nos demeures rurales, pour l'embellissement de notre contrée et dans l'intérêt du tourisme. Le conférencier a été remercié par M. Raphael Rousseau, Agronome Officiel du comté de Bagot.

L'assemblée a ensuite procédé à l'élection des officiers de l'exécutif pour l'année 1929-30. M. P.-N. April, Agronome du comté de Châteauguay a été élu président, M. Lucien Therrien, de Montréal, Vice-président et M. P.-H. Vézina, professeur à Oka, secrétaire.

Dans une courte allocution, le nouveau président, M. P.-N. April, qui est aussi président de l'Amicale des Anciens Elèves de Ste-Anne de la Pocatière et du Comité du Monument Pilote, a invité tous les amis de l'Agriculture à s'unir pour élever à l'abbé Pilote un monument digne de lui et de son oeuvre. Messire François Pilote, dit-il, fut le fondateur de l'Ecole d'Agriculture de Ste-Anne de la Pocatière, la première école de ce genre au Canada et la seconde en Amérique. Il fut donc le pionnier de l'enseignement agricole en ce pays.

J.D.B.

Book Review

Agricultural Economics, by George O'Brien. (Longmans, Green & Co., Toronto, Ont. $4.20).

This book is a definite contribution from a new and welcome source, to some phases of the comparatively youthful subject of agricultural economics. The aim and accomplishment is a somewhat abstract treatment of the subject. No formidable array of tables or charts repel the reader, while references, for the most part, clearly set forth the source of the data upon which the conclusions are based.

Parts which appear particularly well done are the definition given to agricultural economics, and the need for and existence of public policies in regard to agriculture in all countries, though these policies may vary in different places.

The field treated is well defined. There is no wandering from the limits definitely stated in the introduction. The economics of the craft and the business of agriculture are the subjects discussed. Closely related subjects, such as rural sociology, land economics, and economics of population are not included.

In title only, however, is there revealed any marked similarity to the usual treatments of this subject. This is no general criticism. The marked difference is on account of what the author decides to exclude as well as include in the subject. The major portion of the book treats of such subjects as the size of the farm, farm layout, degree of diversity and marketing. These subjects are frequently treated in special texts. This is the more striking as the author disclaims any intention of confining his attention to farm management in the introduction. While perhaps no definite division of these subjects is possible or necessary, it may be suggested that if the subjects enumerated are not farm management then that subject will be confined within somewhat narrow limits.

It is clear that the size of the farm is a problem of interest to the State as well as to the individual operator. This is pointed out as is also the fact that the size of the unit is much more imporatnt in new countries than in older and more permanently settled ones. That land tenure is

not fixed and definite even in old countries is alluded to by the necessity for reorganization in Britain at present. The author favors land nationalization rather than peasant ownership as offering greater hope of efficient farming.

Though reference to the United States is frequent, Canada receives little notice in this book. This is only to be expected. It is unfortunate, however, that among the few references to Canada should be included the claim that the average yield of wheat per acre for Canada is 11.4 bushels. Where this obviously incorrect figure was discovered is not definitely stated in the text, and is likely to remain a mystery. It is true if the searcher wished to find a low yield per acre, an even lower figure might have been obtained for some particular year. More important are the average yields over a period of years. The yield for the five year period from 1922-26 was 17.3 bushels per acre*; that of the period 1917-21, 12.75 bushels†; and from 1901-1913, 19.8 bushels‡.

On the aspects of the subject included in the treatment this book contains a detailed, logical and condensed treatment of considerable merit and of distinct service in a field as yet rather inadequately supplied.

J.E.L.

* Bureau of Statistics, Ottawa.
Monthly Bulletin of Agricultural Statistics, Jan. 1928.

† Monthly Bulletin of Agricultural Statistics, Jan. 1923.

‡ United States Dept. of Agr. Agriculture Year Book,1923, p. 608.

CONCERNING THE C.S.T.A.

Notes and News

R. C. Brown (Manitoba '26), who has been Secretary of the United Farmers of Manitoba for the past two years, is now farming at Pilot Mound, Man.

W. C. Cameron (British Columbia '25) has joined the staff of Central Creameries Ltd., Calgary, Alta.

W. G. Dunsmore (McGill '20), Senior Sheep and Swine Grader under the Dominion Live Stock Branch, has been transferred from Toronto, Ont., to Calgary, Alta.

E. C. Beck (Toronto '28) has changed his address to 163 Brookdale Avenue, Toronto 12, Ont.

H. L. Brouillard (Laval '26) is now County Agriculturist for Lake St. John (District No. 3) with headquarters at Normandin, Lake St. John, P.Q.

G. L. Giasson (Montreal '25), Insect Pest Investigator under the Dominion Entomological Branch, has been transferred from Chatham, Ont., to Montreal. His mailing address is 236 McDougall St., Outremont, Montreal, P.Q.

J. D. Lanthier (McGill '25) is in charge of live stock advertising for the *Canadian Countryman*, Toronto, Ont. He was erroneously reported in the April issue of *Scientific Agriculture* as being on the staff of the *Ontario Farmer*.

M. Syrotuck (Alberta '27), Senior Live Stock Promoter under the Dominion Live Stock Branch, has been transferred from Calgary to Edmonton, Alta.

J. M. A. St. Denis (Montreal '26) has been appointed Inspector of Demonstration Farms under the Field Husbandry Branch of the Quebec Department of Agriculture, with headquarters at Quebec, P.Q.

J. H. Bredin (Saskatchewan '22), who has been taking graduate work at Columbia University in economics and marketing, has received an appointment as Assistant in Statistics, Department of Economics, Northwestern University, Evanston, Ill. U.S.A.

J. P. Fleury (McGill '25), District Live Stock Promoter under the Dominion Live Stock Branch, has been transferred from Sherbrooke to Montreal. His mailing address is 962 Chevrier St., Montreal, P.Q.

G. R. Paterson (Toronto '24), Agricultural Representative for Huron County, Ont. since 1926, has been transferred to Peel County, with headquarters at Brampton, Ont.

The following members of the staff of the Dominion Entomological Laboratory, Chatham, Ont., have been transferred to the Dominion Entomological Branch Parasite Laboratory, Belleville, Ont.:—A. B. Baird (Toronto '16), C. W. Smith (Toronto '24), L. J. Briand (Laval '21), W. E. Steenburgh (Toronto '27), A. R. Graham (McGill '23), George Wishart (Toronto '24).

J. A. Plante (Laval '17), County Agriculturist for Portneuf County (District No. 2), has changed his mailing address to Pont Rouge, P.Q.

C. R. Mitchell (McGill '24) has changed his address to 64 Cowan Avenue, Toronto, Ont. He is Chemist for Cross & Blackwell (Canada) Ltd.

Jacob Biely (British Columbia '26) is taking graduate work at the Kansas State Agricultural College. Until the end of July his address will be 1010 Moss Street, Manhattan, Kansas, and he expects to resume his duties as Research Assistant in the Poultry Dept., University of British Columbia, on Sept. 1, 1929.

F. E. Foulds (Toronto '16) has received his M.A. from the University of Toronto and his M.Sc. from the University of Manitoba. He has resumed his duties as Supervising Analyst under the Dominion Seed Branch, Winnipeg, Man.

J. R. Pelletier (Laval '27) is Assistant Superintendent at the Dominion Experimental Station, Farnham, P.Q.

W. E. Senn (Toronto '23) who has been Agricultural Representative in the Thunder Bay District, Ontario, since 1926 has been appointed Assistant Secretary, Border Cities Chambers of Commerce, Windsor, Ont.

F. Forsyth (Toronto '14) Agricultural Representative under the Ontario Department of Agriculture, has been transferred from Perth to Walkerton, Ont.

N. S. Smith (Manitoba '15) has been appointed Managing Director of Alsask Chemical Products, Ltd., Calgary, Alta.

W. J. Thomson (Alberta '26) has changed his address to 3609 7-A Street, Calgary, Alta.

E. W. Atkins (Manitoba '26) has joined the staff of the Saskatchewan Wheat Pool, Regina, Sask.

E. G. Bayfield (Alberta '23), who has been taking graduate work at the University of Minnesota, has been appointed a National Milling Company Fellow at the Ohio State College. After June 15th his address will be Ohio Agricultural Experiment Station, Wooster, Ohio, U.S.A.

A. G. Gilbert (Laval '23) is leaving early in July for a trip to Europe. For the following two months his address will be c/o Canadian Pacific Railway, 24 Boulevard des Capucines, Paris, France.

Applications for Membership

The following applications for regular membership have been received since May 1, 1929:

White, R. E. (Toronto, 1922, B.S.A.) Newmarket, Ont.

Hopkins, S. H. (Toronto, 1914, B.S.A.) Trail, B.C.

Black, W. J. (Toronto, 1902, B.S.A.) Montreal, P.Q.

Life Memberships

During the past month, the following members of the C.S.T.A., all Canadian representatives of the N. V. Potash Export My., of Amsterdam, Holland, have become life members of the C.S.T.A.,—

E. K. Hampson (Toronto '15) Hamilton, Ont.

J. E. McIntyre (Toronto '21) Bathurst, N.B.

L. Therrien (Montreal '17) Montreal, P.Q.

The Society now has 7 life members. On May 29th, 1928, the total membership of the Society is 1,084, as compared with 1,023 a year ago.

C.S.T.A. Headquarters Opened

The official opening of the Society's new headquarters took place on Friday, May 10th, 1929, under the chairmanship of Dr. J. H. Grisdale, Deputy Minister of Agriculture for Canada. The new offices, lounge room and board room were accepted, on behalf of the Society, by Dr. E. S. Archibald, President. A brief address was given by Dr. H. Barton of Macdonald College who was President of the Society from 1923 until 1925.

The new offices are located in the new Victoria Building on Wellington Street, Ottawa, and C.S.T.A. members should feel free to visit them, and make free use of them, at any time.